TRINITY RIVER BASIN FISH AND WILDLIFE TASK FORCE

TRINITY RIVER
INSTREAM FLOW STUDY

LEWISTON DAM TO THE NORTH FORK

JUNE/JULY 1978

(photo deleted)

FINAL REPORT

of the:

U.S. FISH AND WILDLIFE SERVICE

SACRAMENTO, CALIFORNIA

JANUARY 1980

Foreword

This report was prepared for the Trinity River Basin Fish and Wildlife Task Force to provide information on the current status of fisheries habitat in the Trinity River between Lewiston Dam and the North Fork Trinity River confluence, and to assist the Task Force in reaching a decision as to what levels of flow would assist efforts to achieve the restoration and long-term conservation of Trinity River salmon and steelhead resources.

Several agencies and individuals and groups outside of the U.S. Fish and Wildlife Service played vital roles in various aspects of the study. The following deserve special recognition:

California Department of Water Resources

-- Ed Barnes
-- Ralph Hinton
-- and others

California Department of Fish and Game

-- Paul Hubbell
-- Ed Miller

Trinity County Youth Conservation Corps

-- Roger Hardison
-- and enthusiastic Corps members

My thanks to those above, as well as to those within the U.S. Fish and Wildlife Service who contributed to the completion of this study and especially to those in Cooperative Instream Flow Group whose efforts have advanced the technologies of instream flow assessment.

J.P. Hoffman
U.S. Fish and Wildlife Service
Sacramento, California

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Summary

This is a report to the Trinity River Basin Fish and Wildlife Task Force on the results of an instream flow study conducted on the Trinity River between Lewiston Dam and the North Fork. The study was undertaken during the summer of 1978 with the cooperative assistance of the California Department of Water Resources. The purpose of the study was to assess the opportunities for improving habitat for salmon and steelhead trout by increasing flow releases from Lewiston Dam. Historically the 39-mile long study area (as well as the river above Lewiston Dam) was important for the production of salmon and steelhead trout. Since completion of Lewiston Dam in 1963, the quantity and quality of salmonid habitat in the study area has been degraded by low streamflows (high rates of diversion to the Sacramento River Basin), sedimentation, and vegetation encroachment.

The flow study utilized methodologies developed by the Cooperative Instream Flow Service Group (USFWS, Ft. Collins, Colorado) to predict changes in the amount of fish habitat resulting from incremental changes in river flow. The habitat available for salmonid adult holding, spawning and juvenile rearing life stages was determined at flows between 150 and 1,000 cubic feet per second.

Based on analysis of study results, it was concluded that substantial gains in habitat for some of the more critical life stages could be obtained by increasing flow releases from Lewiston Dam above the present rates varying from 150 to 250 cubic feet per second (CFS) to higher base levels seasonally ranging from 300 to 500 cfs. However, it was noted that, in some cases, habitat gains for some life stages would occur at the expense of concurrently decreasing available habitat for other life stages.

The following flow schedules were developed in consideration of habitat needs for important coinciding life stages of salmon and steelhead trout. Initial base flow recommendations considered the river channel in its present configuration, whereas the recommendations for ultimate flow releases assumed implementation of a mechanical stream channel improvement program. The Lewiston release requirements are predicated on the continued inflow from tributary streams to meet total river flow requirements below Lewiston Reservoir.

Base Release Requirements (Cubic Feet per Second)

Period	Initial Release	Ultimate Release
January - May	300 cfs	400 cfs
June	350 cfs	400 cfs
July - August	500 cfs	500 cfs
September	450 cfs	450 cfs
October - December	300 cfs	400 cfs
Total	254,000 Acre-Feet	308,000 Acre-Feet

The distribution of flows under the proposed versus present schedules is shown in Figure 1.

Additional blocks of water to assist migration of adult steelhead during the fall and winter and to stimulate juvenile salmon and steelhead outmigration during the spring months were estimated. Available information did not permit the precise determination of the migration flow requirements. The exact timing and magnitude of releases adequate to promote the desired migrations would be dependent upon prevailing water runoff conditions each year, therefore the water needs for these purposes were estimated by blocks by season as follows:

Estimated Additional Water Needs (Acre-Feet)

Period	Upstream Migration	Downstream Migration
January - March	9,000 A.F.	-
April -May	-	18,000 A.F.
November - December	6,000 A.F.	-
Total	33,000 A.F.	

As the river channel continues, as a dynamic system, to change in response to altered flows and sedimentation rates, and as fishery management knowledge increases, adjustment in seasonal distribution of flow releases may be necessary to most fully maximize benefits to salmon and steelhead trout.

The initial annual flow requirements total 287,000 acre-feet versus approximately 340,000 acre-feet ultimately. It is recommended that, in the interim until ultimate base flow allocations are required, the difference of 53,000 acre-feet (340,000 minus 287,000 acre-feet), be utilized as needed for experimental purposes. In recognition of the natural occurrence of drought years and other established uses of Trinity River water by the Central Valley Project, various alternatives could be developed that would result in greater reductions in fishery releases and fish production during dry or critical years and thereby minimize impacts on firm yield of the Central Valley Project. The acceptability of any such alternative would need to be judged by the extent and frequency of flow reduction and whether the overall objective of anadromous fish restoration could still be obtained.

It is recommended that implementation of the above flow schedule be followed by a study program to assess the response of the salmon and steelhead populations to improved habitat conditions and to determine what subsequent flow adjustments, if any, and other measures are necessary to most effectively meet fishery resource management objectives.

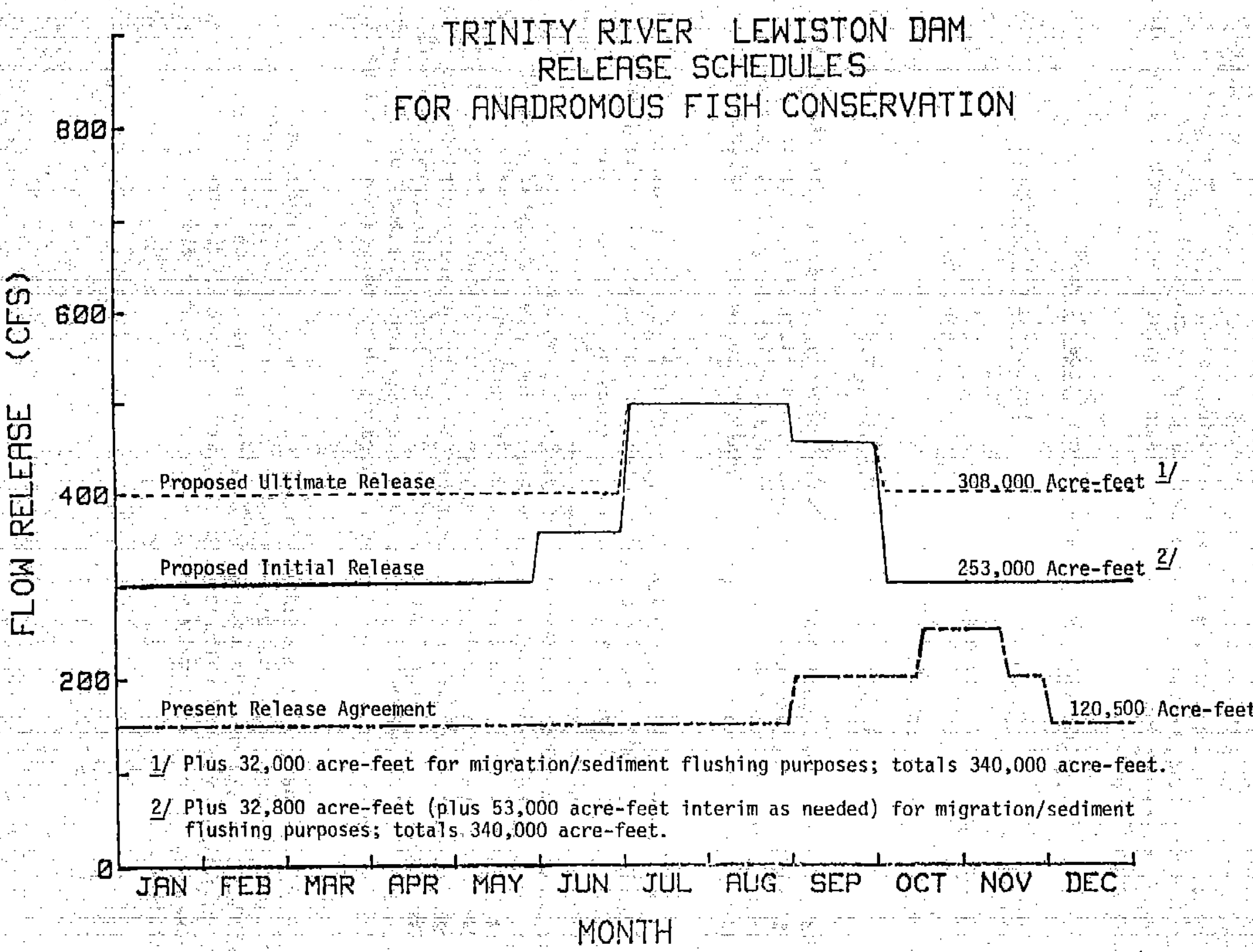

TRINITY RIVER LEWISTON DAM
RELEASE SCHEDULES
FOR ANADROMOUS FISH CONSERVATION
FLOW RELEASE (CFS)
800
600
400
200
0
Proposed Ultimate Release
308,000 Acre-feet 1/
Proposed Initial Release
253,000 Acre-feet 2/
Present Release Agreement
120,500 Acre-feet
1/ Plus 32,000 acre-feet for migration/sediment flushing purposes; totals 340,000 acre-feet.
2/ Plus 32,800 acre-feet (plus 53,000 acre-feet interim as needed) for migration/sediment flushing purposes; totals 340,000 acre-feet.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
MONTH

Figure 1

Introduction

The Trinity River Basin comprises a 2,965 square-mile watershed in Trinity and Humboldt Counties in northwestern California. It has been altered substantially by man's activities during the past century and particularly during the last three decades. During this period anadromous salmonid fishery resources in the basin have severely declined. Losses have occurred in the quantity and quality of instream habitat and in the size of the populations of salmon and steelhead. Activities such as the construction of dams and roads, water export, logging, mining and other land use practices which resulted in habitat destruction are among the principal causative factors suspected in fisheries declines. Overfishing and excessive predation are also suspected of contributing to depressed populations. Several fisheries investigations have been completed by the California Department of Fish and Game and the U.S. Fish and Wildlife Service in cooperation with the land management agencies and other interests. Additional studies are underway. Most of these efforts have been directed toward objectives of estimating run size, sport and commercial harvest, determining timing and success of juvenile and adult migrations, or estimating spawning habitat areas under flow conditions existing at the time of study. This report seeks to complement the efforts of others by investigating the relationship between riverflow levels and habitat available for the various freshwater phases of the life cycle of anadromous salmonids [1/].

The results of this study are useful for development of a flow release schedule to aid in the restoration and conservation of anadromous salmonid fisheries resources in the Trinity River Basin consistent with the intent of Congress in authorizing the Trinity River Division, and with the goals of the Trinity River Basin Fish and Wildlife Task Force. However, it should be clearly recognized that these studies were made in a river channel that in many cases is believed to be nearly "dead" for purposes of production of chinook salmon and steelhead trout. As the river channel continues to change as a result of improved flows and land use practices some adjustments of releases will be necessary to most beneficially utilize available habitat. The data presented here indicate what habitat can now be salvaged with increased flows; it does not guarantee that the limited amount of habitat gains which can be obtained through increased flows will be sufficient to fully achieve restoration of anadromous runs without improving other resource management activities. But, it is equally evident that the present flows have not been sufficient to maintain habitat in the mainstem--even in those areas which have not been more seriously affected by logging or other land uses.

1/ This is a special report to the Trinity River Basin Fish and Wildlife Task Force and is not intended to be construed as a report of the U.S. Fish and Wildlife Service under provisions of the Fish and Wildlife Coordination Act.

Historical Perspective

The 39 miles of the Trinity River from the North Fork Trinity River to Lewiston Dam contains most of the remaining important chinook salmon habitat in the mainstem. This area also has important habitat for holding and rearing steelhead trout and coho salmon. It has been estimated that prior to completion of the Trinity River Division of the Central Valley Project by the U.S. Bureau of Reclamation in 1963, an additional 59 miles of chinook salmon habitat and 109 miles of steelhead trout spawning and nursery area, plus an undetermined amount of coho salmon habitat, existed upriver from Lewiston Dam.

The Trinity River Salmon and Steelhead Hatchery was constructed to offset the loss of production from areas upriver from Lewiston Dam. To date, the hatchery has not been successful in offsetting losses in terms of numbers of adult fish returning to spawn. Smith (1976) reports the 7-year average (1968-1974) returns of chinook salmon as about 6,500 fish or just over half the 12,000 fish estimated to have formerly spawned above Lewiston Dam. Returns of steelhead trout to the hatchery during the five-year period 1971-1975, averaged only 223 fish which is about 6% of the average steelhead trout run of 3,000 fish during the six years (1958 to 1964) immediately preceding the project (Department of Water Resources, 1978). Steelhead trout returns over the past three years have shown a slight improvement increasing to an average of 327 fish (10% of pre-project levels), with 13 returning in 1977, 285 in 1978, and 683 in 1979 (G. Bedell, DFG, personal communication).

In addition to blockage of access to upriver habitat, Lewiston Dam and Reservoir have functioned as a diversion point for water export for the Central Valley Project (CVP). An average of 85-90% of the annual river flow from the upper 720 square miles of Trinity River Watershed has been diverted for CVP use in the Sacramento-San Joaquin Basins with the remaining 10-15% of the runoff being released from Lewiston Reservoir for fishery conservation purposes or controlled spills. The present flow schedule for the Trinity River is shown in Figure 1. Established base flows are 150 cubic feet per second (cfs), increasing to 250 cfs during the peak chinook salmon spawning period.

Low base flows in combination with decreased annual flood flows to maintain the configuration of the former river channel stimulated the rapid encroachment of riparian vegetation. Changes in channel morphology resulting from decreased flows below Lewiston Dam were further amplified by accelerated erosion which resulted from logging and road construction in geologically unstable tributary watersheds. Sediment loading into the mainstem Trinity River increased. The pre-project sediment bedload carrying capacity of the Trinity River was reduced from 200,000 cubic years per year to about 10,000 cubic years per year after project completion (Resources Agency, 1970). Sediment accumulation filled pools, compacted riverbed gravels and further encouraged encroachment of riparian vegetation. By 1970 the resultant loss of spawning habitat was estimated at 44% of that existing in the same area two and a half decades earlier (Hubbell, 1973). Channel deterioration continued through the 1970's with tributary deltas restricting the main river channel, impeding flows and forming shallow sandy-bottomed, "tule-lined" pools bearing little resemblance to the anadromous salmonid habitat that historically existed.

Because of limited historic data and the interaction of Man's activities (logging, mining, water diversions) in reducing habitat, the precise losses of anadromous fish production in the Lewiston to North Fork reach which are attributable to impacts of the Trinity River Division or any one of the other recent developmental activities in the Trinity Basin are not known. However, the relative trend in terms of declining numbers of adults returning to spawn in the river are well recognized. Post spawning season salmon carcass counts have been substantially lower in recent years than in pre-project years in spite of improved carcass recovery capabilities at present low flows.

Chinook salmon spawning runs into the Trinity River (including Trinity Hatchery) during the 1972-1974 period were estimated to have averaged about 20,000 fish (Data unpublished, Hubbell, DFG, personal communication) which is about 37% of the 54,000 average estimated for the pre-project years of 1955 and 1956 (Hubbell, 1973). Another report indicates chinook salmon spawning in the Trinity River during 1974-1976 was only 13% of the level during 1969-1973 (DWR, 1978). The river spawning portion of the run has declined further in most recent years. An increase to 7,000 occurred in 1978, but the run sagged to approximately 1,200 again in 1979 (E. Miller, DFG, personal communication).

Although the Trinity River was more suitable for angling for longer periods because of reduced flows, the estimated total sport harvest of chinook salmon in the Trinity River dropped by 50 percent between the periods of 1956-1958 and 1968-1969 while steelhead trout harvest was estimated to have decreased 88 percent during the same interval (Hubbell, 1973).

The Trinity River Basin Fish and Wildlife Task Force received funds beginning in 1976, to determine and carry out, where possible, measures necessary to resolve problems responsible for continuing declines in fish and wildlife resources in the Trinity Basin. Numerous studies and activities were conducted including watershed revegetation for erosion control, mechanical restoration of mainstem riffle and pool habitat, tributary stream improvement, sediment transport and removal studies, and fish population, migration and harvest assessments.

In the spring and summer of 1978 an instream flow study was undertaken cooperatively by the California Department of Water Resources and the U.S. Fish and Wildlife Service, with assistance from the California Department of Fish and Game, Trinity County Youth Conservation Corps Project, and the U.S. Bureau of Reclamation. The results of the instream flow study are presented in this report.

Description of the Study Areas

Within the 39 mile reach of the Mainstem Trinity River between Lewiston Dam and the North Fork, six representative study areas were selected for the instream flow study (Plate 1). The study areas varied in length from 700 to 2,900 feet and were located from 6.0 to 36.5 miles downstream from Lewiston Dam (Table 1).

The uppermost study area, called Bucktail, was located 6.0 miles downstream from Lewiston Dam and consisted of upper and lower sections separated by two restored spawning riffles (Riffles F and G). Seventeen cross section study stations were established in this area which had undergone serious channel constriction as a result of vegetation encroachment.

The second study area was located about two miles downstream from Grass Valley Creek at Poker Bar. Four stations were established in this area. Grass Valley Creek is recognized as a major contributor of sand-sized sediment (decomposed granite) to the Trinity River (DWR, 1978), and the Poker Bar stations were representative of the habitat deterioration attributable to sedimentation.

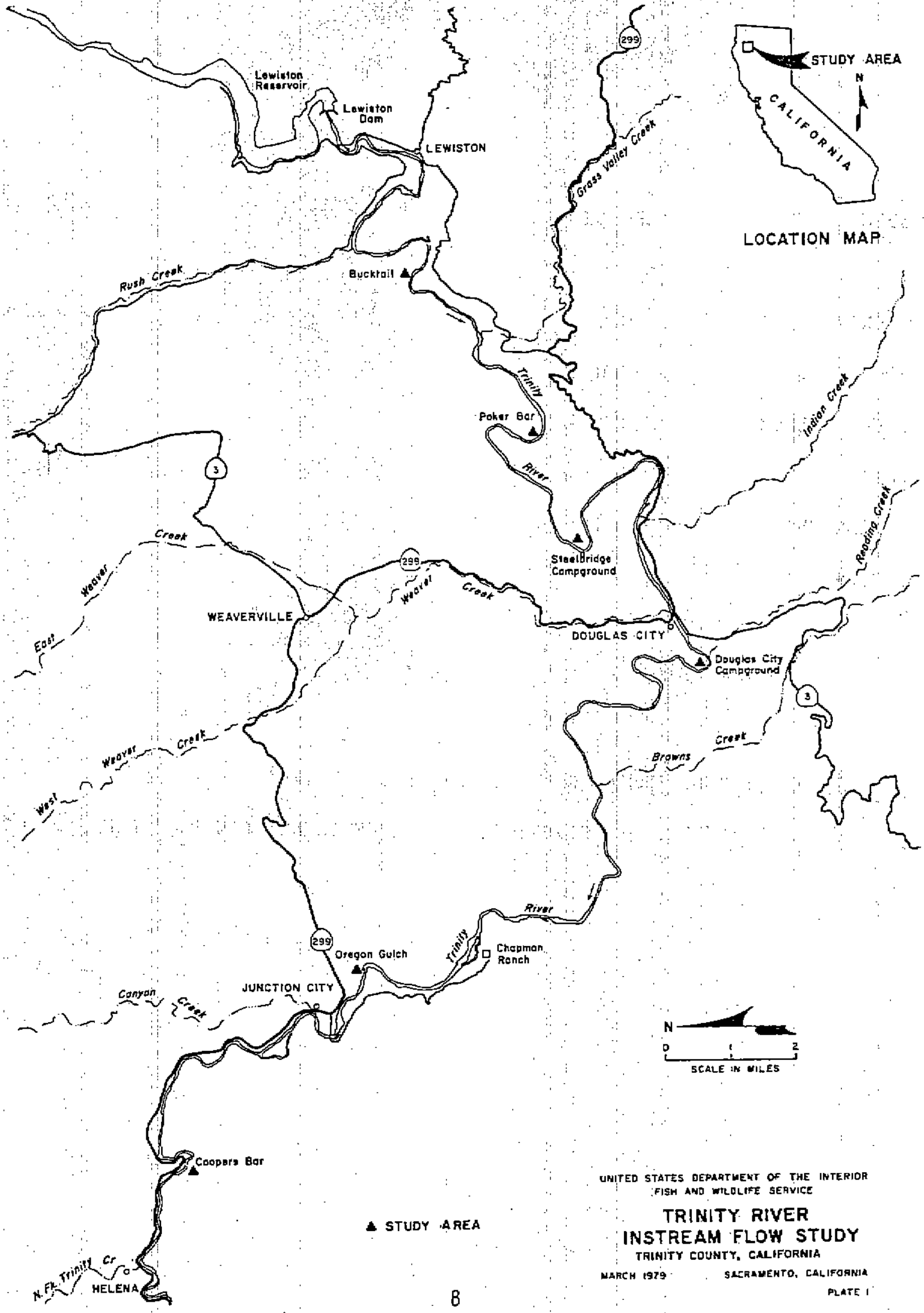
A third study area was chosen near Steel Bridge Campground near the end of Steel Bridge Road. The study area began approximately 12.5 miles downstream from Lewiston Dam. Ten study stations were established in the Steel Bridge reach which, at that time, had been only moderately affected by sedimentation. (From visual observations of the study area during the spring and summer of 1979, it appeared significant habitat losses had occurred due to river transport of sand sediments into the area.)

The fourth study area, with eight stations, was located near Douglas City Campground approximately 19.5 miles downstream from Lewiston Dam. The Douglas City reach represented conditions of increasing river gradient and bed-rock outcroppings typical of those occurring between Douglas City and Junction City. Indian, Weaver, and Reading Creeks, all important tributaries for steelhead, enter the Trinity River from one-quarter to three miles upriver from the Douglas City study area and provide substantial inflow during winter and spring months.

Another study area consisting of six stations was established approximately 30 miles downstream from Lewiston Dam just downstream from the confluence of Oregon Gulch. This reach of the river was apparently formerly used by spawning chinook salmon (Moffett and Smith).

The lowermost study area with eight stations was located at Coopers Bar (also known as Lime Point) about one and one-half miles downstream from Canyon Creek. Canyon Creek is a major tributary of the Trinity River with sustained flows high enough to help maintain pool habitat but not to prevent some vegetation encroachment along the riffles and runs.

Additional streamflow data, collected by the Department of Water Resources, on two restored spawning riffles located between Lewiston Dam and the Bucktail Study Area were assessed to provide a more fully representative



UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

TRINITY RIVER
INSTREAM FLOW STUDY
TRINITY COUNTY, CALIFORNIA

MARCH 1979 SACRAMENTO, CALIFORNIA

PLATE I

TABLE 1

TRINITY RIVER

INSTREAM FLOW

STUDY AREAS

AREA	LENGTH 1/	NO. STATIONS	RIVER MILE 2/
BUCKTAIL	2900	17	6.0
POKER BAR	700	4	9.5
STEEL BRIDGE	2000	10	12.5
DOUGLAS CITY	2000	8	19.5
OREGON GULCH	1100	6	30.5
COOPERS BAR	800	8	36.5

1/ LENGTH OF STUDY REACH GIVEN IN NEAREST 100 FEET.

2/ RIVER MILE GIVEN AS APPROXIMATE DISTANCE DOWNSTREAM FROM LEWISTON DAM.

sample of conditions occurring on the restored riffles. The means of data collection did not allow these additional areas to be assessed consistent with methods used for the other areas but was sufficient for empirical estimates of habitat availability at four measured flows.

Methods

The instream flow assessment method employed for this study was patterned after that developed by the Cooperative Instream Flow Service Group (IFG) of the U.S. Fish and Wildlife Service (Bovee, 1978). The methodology predicts the suitability of stream habitat for fish of a given species and life stage as defined by combinations of depth, velocity and substrate occurring within a range of specified stream discharges. The applicability IFG methodology is predicated on several important assumptions, including:

A. Physical variables of depth, velocity, temperature and substrate are important quantifable parameters affecting fish production which change with streamflow. Other important parameters affecting fish production such as water chemistry and light are assumed constant or handled with separate models;

B. The probability that fish will choose to live in association with any particular stream condition of depth, velocity or substrate can be described independently;

C. That there is a direct relationship between the availability and actual use of the habitat by fish;

D. That habitat changes over a range of flows within a homogeneous reach of a river will correspond to the changes observed by study of a chosen representative segment (area) within the reach; and

E. The hydraulic force of the selected flow regime will not alter the stream channel.

The six representative study areas were selected and 53 study stations (transects) were established during May and June 1978 using the following procedures: homogeneous river reaches were determined based on a review of topographic maps, and analysis of aerial photos. Assistance with these efforts was provided by the California Department of Fish and Game and the California Department of Water Resources. Aerial reconnaissance and on-site inspections of each candidate study area were employed to eliminate duplication of study areas and to determine access for field work. After the study areas were examined, a representative workable length of stream was selected and adequate number of stations established within the limits of time, manpower, and equipment constraints.

Transect stations were established to cover habitat types (riffles, runs, pools) and all major hydraulic controls (channel confinements which affected upstream water levels).

The lower-most transect on each reach was located at a hydraulic control to improve simulation of riverflow movement and to provide a good estimate of river discharge during each period of field data collection. Once the cross section stations were selected, each study area was surveyed to determine elevations of reference headstakes at each transect and stream centerline distances (stationing) between transects.

Data collection periods ran from late June through July 1978, during alternating weeks. Field data were collected at each station for consecutive periods of pre-arranged flow releases from Lewiston Dam of approximately 300, 600, and 800 cfs. (Actual flows at each study area varied depending on amount of tributary inflow.)

A steel cable was stretched across the river, perpendicular to the flow of the river at each study station. End stakes for cable attachment were placed on each river bank above the estimated high study-flow level. A reference zero point was established at one of the end stakes. If the river channel was less than 200 feet wide, water velocity and depth measurements were taken every 3 feet (ft.) between the banks (Figure 2). Where the width of the river exceeded 200 feet, 6 ft. measurement intervals were used.

Velocities were measured as mean column velocity with one measurement taken at 0.6 total depth (from surface) if the depth was 3 feet or less, or the average of two measurements taken at 0.2 and 0.8 total depth, if the depth exceeded three feet. Most velocity measurements were taken using Price-Type AA current meters. A limited number of measurements were taken with a Marsh-McBirney electronic flow-averaging meter. Depths were measured to the nearest 0.1 ft. using top-setting wading rods where possible. Weighted (50 lb.) suspension cables were used from boats to obtain depth and velocity measurements in deeper waters (cover photo and Figure 3).

During the 300 cfs measurements, substrate conditions were evaluated at each established measurement interval (3 ft. or 6 ft.) either visually or by scraping the riverbed to estimate sizes and mixtures of substrate materials. Substrate values were recorded using a graduated Modified Wentworth scale of 1 to 8 (Table 2).

Relative water surface elevations at each transect within the study area were referenced to an arbitrary datum (benchmark) using an engineer's level and a stadia rod. A set of water surface elevations was made each time velocity and depth measurements were taken at the study stations (Figures 4 and 5).

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TABLE 2

TRINITY RIVER INSTREAM FLOW STUDY
SUBSTRATE EVALUATION SCALE 1/

SCALE VALUE	SUBSTRATE TYPE	APPROXIMATE SIZE RANGE (mm)
1	Plant detritus	-
2	Mud	.06 (deep layer)
3	Silt	.06 (shallow layer)
4	Sand	.06-4
5	Gravel	4-130
6	Rubble	130-220
7	Boulder	220-4000
8	Bedrock	4000

1/ Size ranges are approximate as used for this study. Substrate conditions were ranked qualitatively as being either within or as mixtures of these categories based on visual and touch observations made during low flow (300 cfs) study period.

Photo page deleted.

Habitat preference curves for use in calculating usable habitat were modified or constructed for the Trinity River salmonid species and life stages of interest. The habitat curves were based on the likelihood of use of a range of velocity, depth or substrate conditions for a particular life stage of a species. Curves developed by the Instream Flow Group were reviewed with fishery management biologists with Region One of the California Department of Fish and Game. Adjustment to various curves were made where believed necessary to more adequately reflect habitat conditions utilized by Trinity River stocks. (For example, Trinity River chinook salmon are smaller than chinook in other river systems and are suspected to use smaller size gravels for spawning.) A curve for evaluating adult chinook salmon holding habitat, which was believed an important factor in the Trinity System, was constructed since an Instream Flow Group Curve was not available for that life stage.

Data coding for computer processing was completed by late November 1978 using procedures outlined in draft Instream Flow Group User Manuals (Main, 1978a, 1978b). Data processing services were provided by the U.S. Bureau of Reclamation, Sacramento, with a link to a main frame computer in Denver, Colorado. Hydraulic simulation of river flows through the study reaches was undertaken using the U.S. Fish and Wildlife Service IFG-4 Program to establish stage (water level) versus discharge (flow volume) relationships (Appendix B).

Usable habitat projections within each study reach were made for a series of simulated flows ranging from 150 to 1,000 cfs using the Instream Flow Group HABITAT Program (Appendix C) and data input from the IFG-4 Program. Primary output from the HABITAT program was weighted useable habitat per five hundred feet of river for each life stage of each species of interest.

The data from the 17 transect stations in the Bucktail Study Area, were subdivided into two groups, Upper Bucktail, Riffle F, Riffle G and Lower Bucktail. This was done to isolate the restored riffle and also because the habitat program capacity was limited to a maximum of ten transect stations per run.

Additional data collected by the Department of Water Resources on two restored riffles (Lower Lewiston and Upper Cemetary) at four flow rates were used to calculate available habitat. The field measurements were not suitable for use in the IFG-Program but could be run directly through the Habitat Program to provide habitat estimates on the riffles at the four measured flow levels.

Development of a recommended flow release schedule from Lewiston Dam was based on considerations of habitat/flow relationships developed with the IFG-4 and HABITAT Programs, the seasonal occurrence and importance of salmonid life stages in the Trinity River, estimates of the need for flows for stimulating and assisting fish migration to and from the ocean portion of their environment, and the estimated "base flow" acretions from tributaries which could be expected to increase the river flow rate within each of the study reaches.

The tributary flow estimates were developed by the California Department of Water Resources using stream gage data where available and standardized procedures for computing discharges in ungaged streams. Base flows were calculated by excluding the 10 highest daily flows each month and averaging the remaining daily flows.

Results

The summarized results of habitat mapping are shown in Table 3. Three major habitat categories were identified; riffles, pools, and runs. Each of these categories was subdivided to reflect the overall quality of the habitat for fish productions. Riffles were categorized based on estimated relative values for chinook salmon spawning and for food production (benthic organisms). Pools were evaluated on the basis of estimated average depths, with deeper pools being considered of value for holding adult chinook salmon prior to spawning. Runs were categorized as those moderate or swift flowing areas which were relatively narrow in width and which did not fit the categories of riffles or pools. The habitat mapping data were indicative of the general overall quality of habitat remaining in Trinity River between Lewiston Dam and the North Fork and were useful for selection of representative study sites within the 39-mile reach.

Riffle area was estimated to comprise about 13 percent (52.8 acres) of the total habitat area (403.5 acres) between Lewiston Dam and the North Fork. Only 3.2 percent of the total riffle area (12.8 acres) was estimated as being of "R1" or "Restored" quality which were considered of prime importance for chinook salmon spawning and food production. Restored riffles were those which were mechanically improved through efforts of the Trinity River Basin Fish and Wildlife Task Force. All but about one acre of the primary riffle area was located in the Lewiston Dam to Douglas City reach, with restored riffles accounting for 3/4 of the identified primary spawning habitat. "R2" riffles were estimated as being of limited value for spawning but were rated important food producing areas. Approximately 4.5 percent (18 acres) of the total habitat area (Lewiston to North Fork) was classified R2. The poorest quality riffle areas, "R3", were considered of no value for chinook spawning and of limited value for food production. The R3 riffles comprised an estimated 5.4 percent (22 acres) of the total habitat area in the Lewiston to North Fork study area.

Pool area was categorized based on estimated average depths. The pools greater than 6 feet deep (including restored areas) comprised 3.3 percent (13 acres) of the total habitat; 4/5 of this prime pool area was located above Douglas City. Moderately deep (3 to 6 feet) and shallow (less than 3 feet) pools accounted for approximately 1/3 (30 percent) of the total river habitat between Lewiston and the North Fork. Runs were the predominant habitat type in the reaches from Douglas City to North Fork, accounting for over 70 percent (150.5 acres) of the area (210.6 acres) in these reaches and approximately 54 percent (216.5 acres) of the total river area between Lewiston and the North Fork.

As previously described, release flows from Lewiston Dam of 300, 600 and 800 cfs were requested for study purposes. The discharge measurements made at each study area during the requested releases are shown in Table 4. The additive and sporadic effects of

TABLE 3
TRINITY RIVER HABITAT INVENTORY
LEWISTON DAM TO NORTH FORK

HABITAT TYPE	LEWISTON DAM TO GRASS VALLEY CREEK		GRASS VALLEY CREEK TO DOUGLAS CITY		DOUGLAS CITY TO CHAPMAN RANCH		CHAPMAN RANCH TO NORTH FORK TRINITY		TOTALS	
	ACRES	%	ACRES	%	ACRES	%	ACRES	%	ACRES	%
POOLS										
P1	4.2	4.6	3.3	3.3	0.9	1.0	0.7	0.6	9.1	2.3
P2	23.4	25.4	7.1	7.0	14.6	15.7	4.1	3.5	49.2	12.2
P3	26.2	28.5	22.6	22.4	14.7	15.8	8.5	7.2	72.0	17.8
RESTORED	3.9	4.2	0.0	0.0	0.0	0.0	0.0	0.0	3.9	1.0
SUBTOTAL	57.7	62.7	33.0	32.7	30.2	32.5	13.3	11.3	134.2	33.3
RIFFLES										
R1	2.8	3.0	0.2	0.2	0.3	0.3	0.6	0.5	3.9	1.0
R2	2.4	2.6	4.2	4.2	6.9	7.4	4.5	3.8	18.0	4.5
R3	3.2	3.5	14.5	14.3	2.6	2.8	1.7	1.4	22.0	5.4
RESTORED	8.9	9.7	0.0	0.0	0.0	0.0	0.0	0.0	8.9	2.2
SUBTOTAL	17.3	18.8	18.9	18.7	9.8	10.5	6.8	5.8	52.8	13.1
RUNS										
T1	8.5	9.2	38.4	38.1	41.0	44.1	75.8	64.4	163.7	40.5
T2	8.5	9.2	10.6	10.5	11.9	12.8	21.8	18.5	52.8	13.1
SUBTOTAL	17.0	18.5	49.0	48.6	52.9	56.9	97.6	82.9	216.5	53.6
TOTALS	92.0	100.0	100.9	100.0	92.9	100.0	117.7	100.0	403.5	100.0
RIVER MILES	7.1		10.3		10.7		10.5		38.6	

HABITAT TYPES (1 OR RESTORED IS BEST, 3 IS POOREST):

P1 > 6 FEET DEEP
P2 3 TO 6 FEET DEEP
P3 < 3 FEET DEEP
RESTORED BY TRBF&WTF

R1 MAJOR SPAWNING, MAJOR FOOD PRODUCTION
R2 MINOR SPAWNING, MODERATE FOOD PRODUCTION
R3 NO SPAWNING, MINOR FOOD PRODUCTION
RESTORED BY TRBF&WTF

T1 SWIFT >3 FPS
T2 SLOW <3 FPS

TABLE 4

TRINITY RIVER INSTREAM FLOW STUDY
LEWISTON TO THE NORTH FORK, 1978
STUDY PERIODS AND ESTIMATED FLOW IN CFS WITHIN STUDY
REACHES DURING SCHEDULED RELEASES
FROM LEWISTON RESERVOIR

Study Period:	June 26-30	July 10-14	July 24-28
Scheduled Lewiston Release:	300	600	800
Measured Release at:			
Bucktail	353	558	744
Poker Bar	386	616	741
Steel Bridge	394	628	804
Douglas City	427	657	811
Oregon Gulch	490	681	802
Coopers Bar	745	885	937

uncontrolled tributary inflow were evident, especially in the lower study areas. Natural snow-melt runoff was decreasing as the study season progressed and the controlled releases from Lewiston Dam increased. This situation tended to reduce the magnitude of flow variation measured in the lower study reaches and resulted in a relatively close grouping of high flows (745, 885 and 937 cfs) at the Coopers Bar study area. Short duration runoff from localized thunderstorms also contributed to variations in river discharge measurements between reaches as did such factors as bank storage and discharge.

The habitat preference curves used for this study (for the HABITAT Program data output) are shown in Figures 6-9. Where modifications were made in existing Instream Flow Group curves for salmonids (Bovee 1978), the changes were usually in the form of either broadening the acceptable range or increasing the use preference factor values for the various evaluative criteria. For example, substrate preference conditions were broadened for adult steelhead trout from a peak use of materials in the 5.7 - 6.3 classes to a peak ranging from about 2.0 to 6.3 (Figure 6). Similarly, substrate and depth factors were liberalized for juvenile steelhead trout as was the range of useable substrate conditions for juvenile chinook salmon (Figure 7). The major exception to the above was in regard to the size of spawning gravels used by Trinity chinook salmon. Because of their known smaller average size relative to stocks in other river systems, the total range of the size of substrate materials considered suitable for spawning was reduced although the range of peak use (the top of the curve) was actually broadened slightly.

The adult chinook curve shown in Figure 7 was constructed using information provided by regional biologists with the California Department of Fish and Game. The curve was utilized for determining the amount of habitat available for holding adult chinook salmon prior to onset of spawning.

No changes were made in the Instream Flow Group curves for coho salmon (Figure 8) and brown trout (Figure 9). A curve for adult coho salmon did not exist and none was constructed since specific requirements were not known. Additionally, a curve existed for coho fry (young emergents) but not for coho juveniles. The coho fry curve was used to get an indication of general habitat conditions even though the data were not directly comparable to those obtained for the juvenile stages of other species.

Relative weighted habitat estimates for various life stages of salmonid species at selected flows are presented on a reach-by-reach basis in Appendix A in tabular form. The data are also presented in graphic form within this report on a species life-stage basis (as straight line plots between analysis points). Discussions of the habitat estimates for each species follow:

TRINITY STEELHEAD

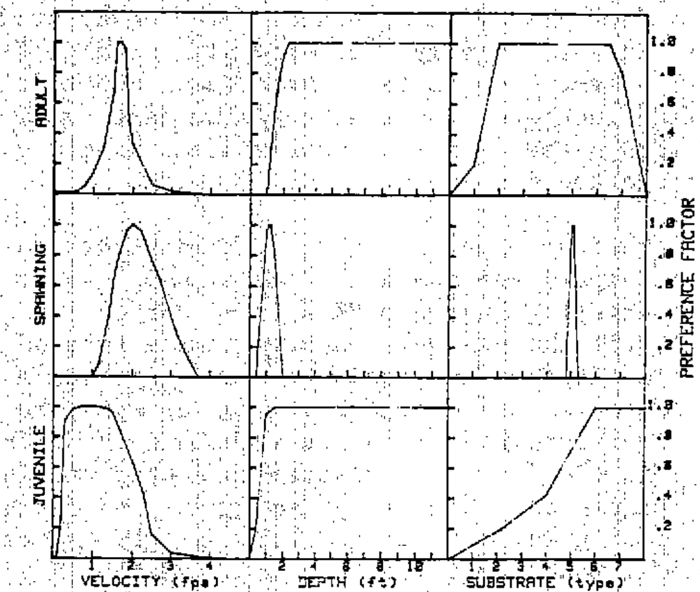


Figure 6

TRINITY CHINOOK SALMON

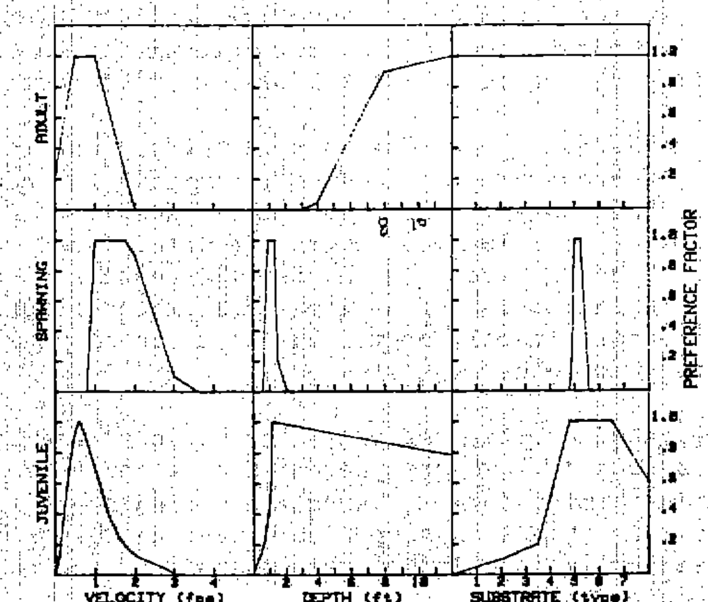


Figure 7

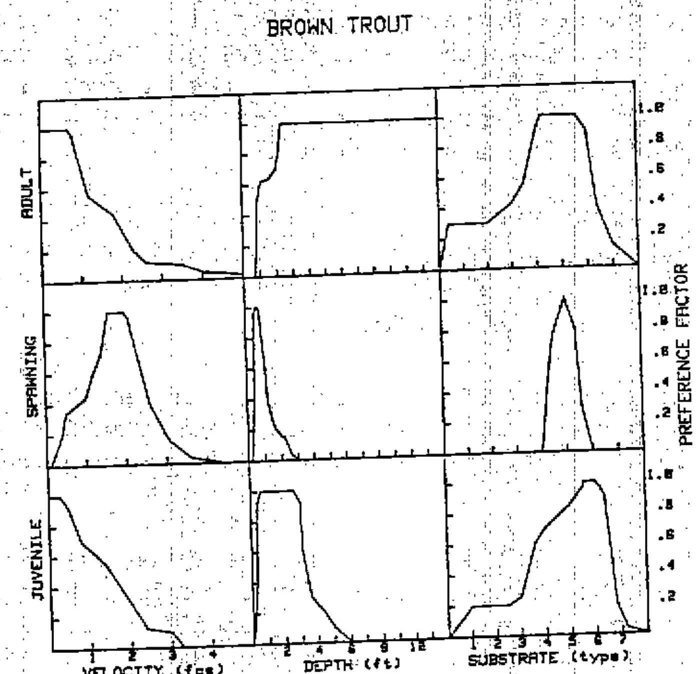


Figure 8

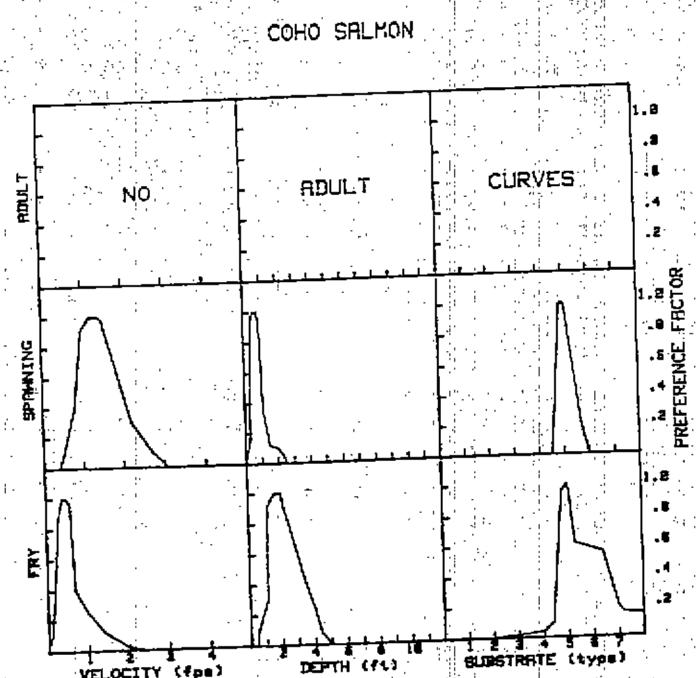


Figure 9

Steelhead trout:

Weighted usable adult steelhead habitat data for the Lewiston to Douglas City Study reaches are presented in Figure 10. Greatest amounts of adult habitat occurred in the Steel Bridge area at a flow of 400 cfs and at Upper Bucktail at a flow of 500 cfs. Lesser amounts of adult habitat were available in the Lower Bucktail and Poker Bar reaches with peaks occurring at 500 and 300 cfs respectively.

Adult steelhead trout habitat in two restored riffle areas is shown in Figure 11. Peak habitat at Riffle G occurred in the range of 150 to 200 cfs. At Riffle F peak habitat occurred at 500 cfs but was still lower than the lowest values obtained for Riffle G.

Adult steelhead trout habitat availability in the study sites downstream from Douglas City is shown in Figure 12. Adult habitat estimates for Douglas City peak at 200 cfs; at 500 cfs at Oregon Gulch; and at 600 cfs at Coopers Bar.

A limited amount of steelhead spawning occurs in the mainstem Trinity River. Available habitat estimates for the four unrestored upper areas are shown in Figure 13. Peak availability occurs at 300 cfs; however, there is relatively little difference within the range of 250 to 400 cfs. Steelhead spawning habitat estimates for the two restored areas are shown in Figure 14; and for the three lower river areas in Figure 15.

Juvenile steelhead trout habitat availability at four sites above Douglas City is shown in Figure 16. Greatest amounts of juvenile habitat occur at Steel Bridge at 400 cfs and at Upper Bucktail at 500 cfs. Lesser amounts of habitat occur at Lower Bucktail and Poker Bar with peaks occurring at 250 cfs and 150 cfs, respectively.

Juvenile steelhead trout habitat availability in the two restored riffle study areas is shown in Figure 17. Peak habitat in Riffle G occurred at 150 cfs and declined rapidly at high flows. Riffle F habitat projections were not consistent. Highest habitat levels occurred at the lowest and highest flow points with less habitat at intermediate flows.

Juvenile steelhead trout habitat availability at the three lower study sites is shown in Figure 18. Habitat estimates decreased steadily at Oregon Gulch above 250 cfs, while levels at Coopers Bar remained relatively level between 150 and 1,000 cfs. Habitat at Douglas City declined progressively at flows above 150 cfs.

Chinook Salmon:

Chinook salmon adult habitat availability in the six study areas above Douglas City is shown in Figure 19. Highest levels of adult habitat occurred at the Upper Bucktail site at 500 cfs. Lesser levels of

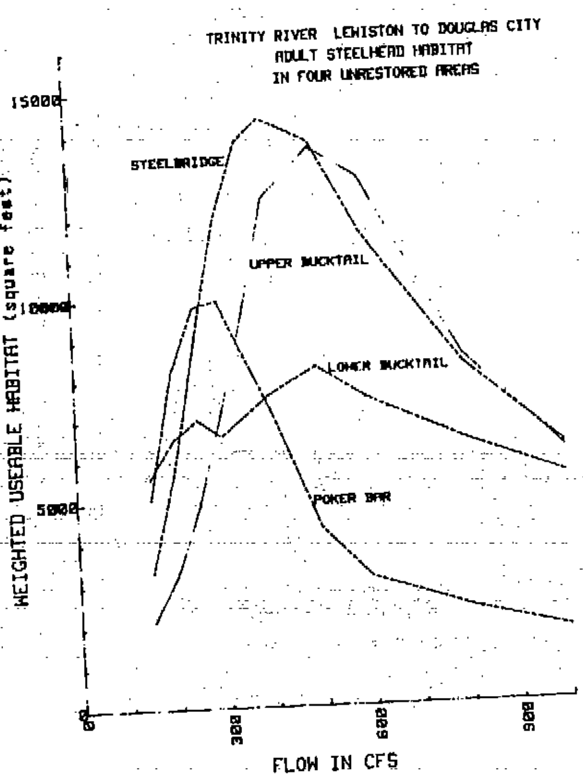


Figure 10

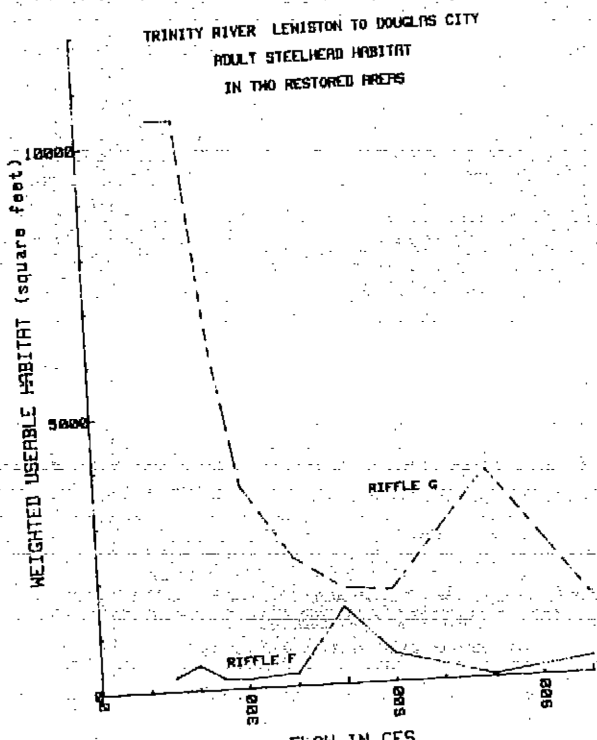


Figure 11

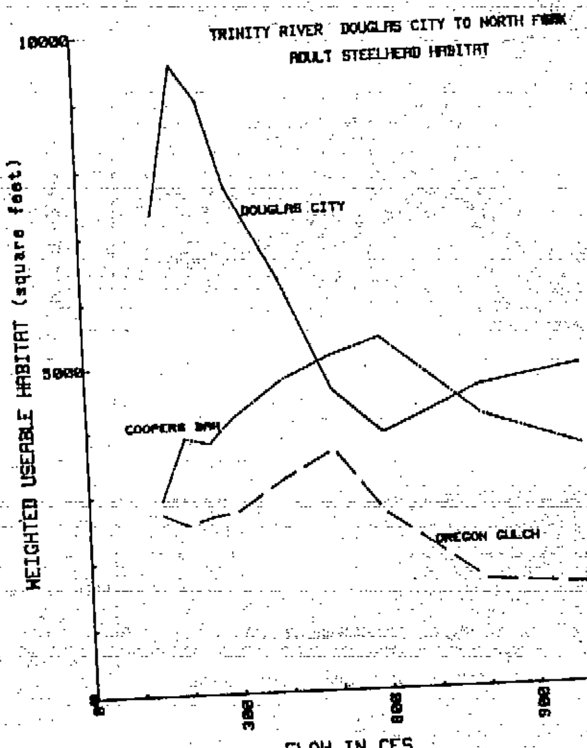


Figure 12

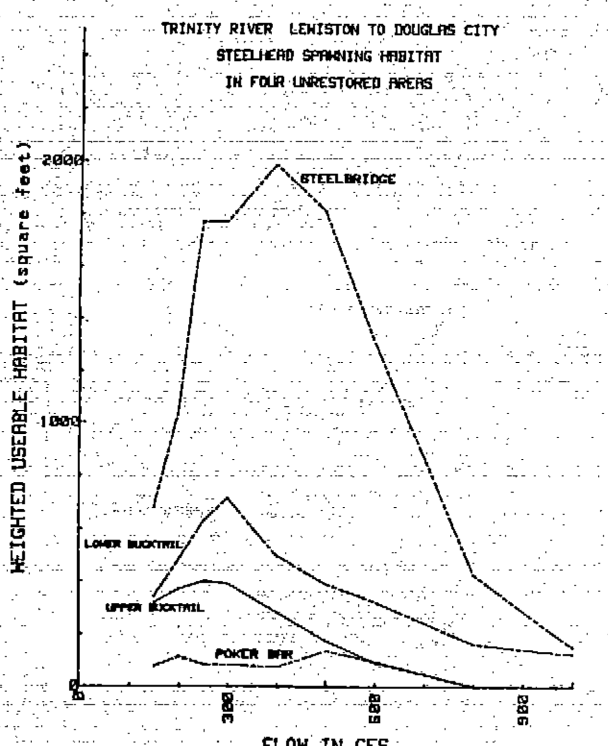


Figure 13

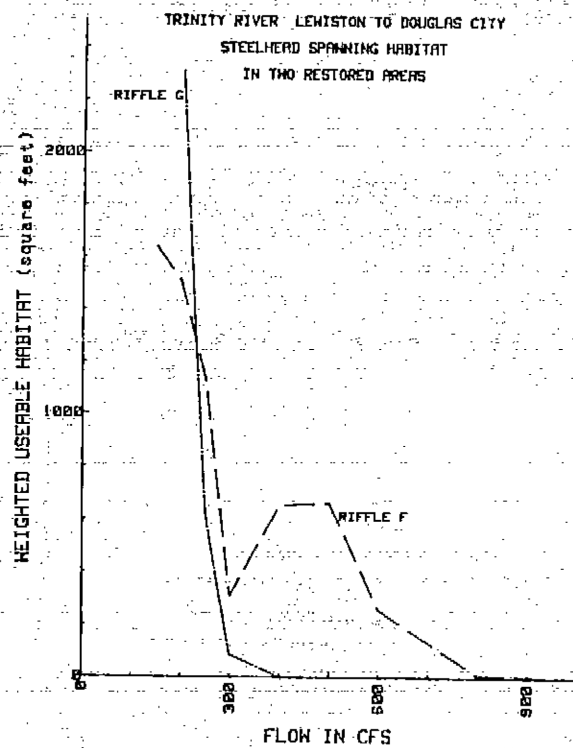


Figure 14

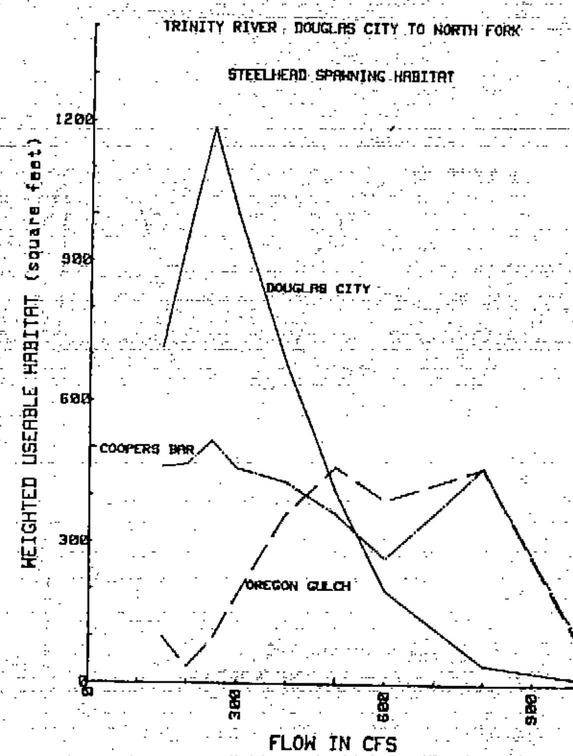


Figure 15

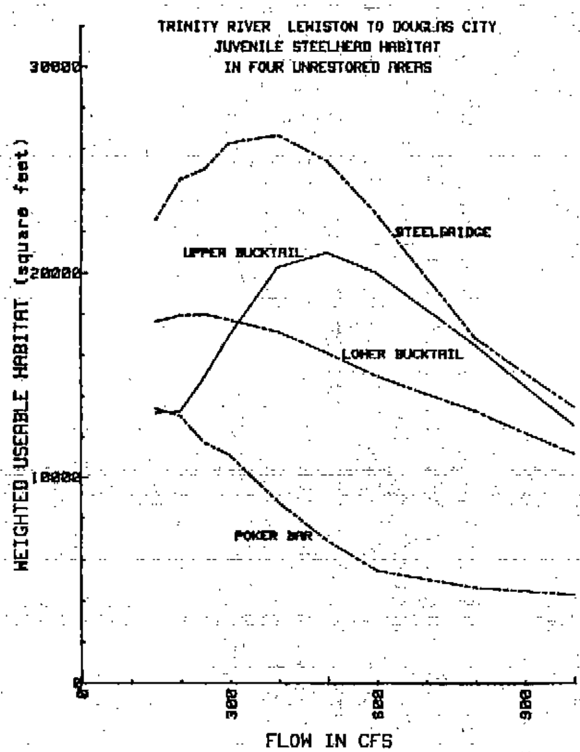


Figure 16

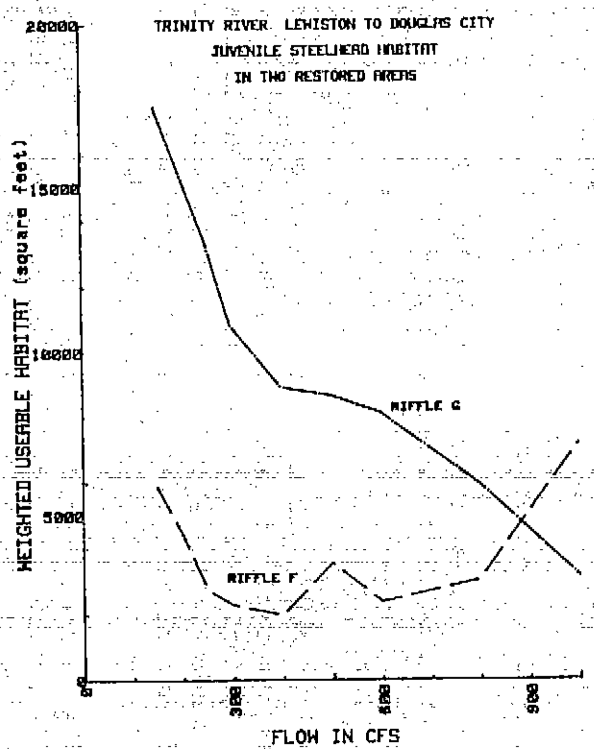


Figure 17

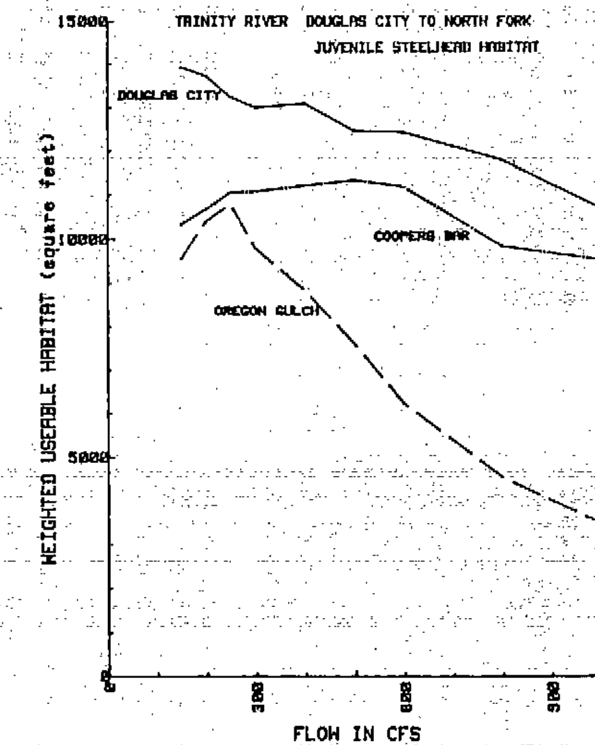


Figure 18

habitat occurred at Lower Bucktail and Steel Bridge with peaks at 300 and 400 cfs, respectively. No adult habitat occurred at the Riffle F, Riffle G, or Poker Bar sites within the 150 to 1,000 cfs flow range.

For the three lower study sites, adult chinook salmon habitat peaked in the 500 to 800 cfs range (Figure 20). Most adult habitat occurred in the Coopers Bar study reach with a sharp peak at 600 cfs. Chinook salmon adult habitat estimates for the Douglas City study reach had a relatively flat peak at 800 cfs. Very little habitat was predicted within the Oregon Gulch reach with a slight peak occurring at 500 cfs.

Chinook spawning habitat esitmates for four areas above Douglas City are shown in Figure 21. Except for the Steel Bridge site, the habitat projections showed very little useable spawning area. Peak habitat availability for the four sites occurred in 150 to 400 cfs range.

Chinook salmon spawning habitat estimates for the two restored riffle study areas are shown in Figure 22. The greatest amount of habitat occurred on Riffle G at a flow of 150 cfs with a decline to zero at and above 350 cfs. Habitat on Riffle F was relatively low compared to Riffle G and peaked at 400 cfs.

Chinook salmon spawning habitat availability in the three areas below Douglas City is shown in Figure 23. Peaks occurred at 250 cfs at Douglas City; at 400 cfs at Oregon Gulch; and at 500 cfs at Coopers Bar.

Juvenile chinook salmon habitat declined with increasing flow at four of the six study areas above Douglas City (Figures 24 and 25). The exceptions were in the Upper Bucktail and Riffle F reaches. The Upper Bucktail site showed peak juvenile habitat availability at 500 cfs and Riffle F showed habitat increases continuing through 1,000 cfs with an intermediate peak at 500 cfs.

Juvenile chinook salmon habitat available in the three lower study areas is shown in Figure 26. Highest levels of habitat occurred in the Douglas City reach at a flow of 600 cfs. The Coopers Bar and Oregon Gulch reaches showed declining habitat levels below 300 cfs.

Coho salmon:

Estimates of available coho salmon spawning habitat are shown in Figures 27, 28, and 29. Most of the habitat in the Steel Bridge study reach occurred at the 250 cfs flow with rapid reductions in useable area at high flows (Figure 27). The other three areas have lesser amounts of coho salmon spawning habitat with peaks occurring below 200 cfs. The two restored riffle study areas had highest levels of habitat in the 150-200 cfs range (Figure 28). Coho salmon spawning habitat at Riffle G declined as flows increased, while habitat

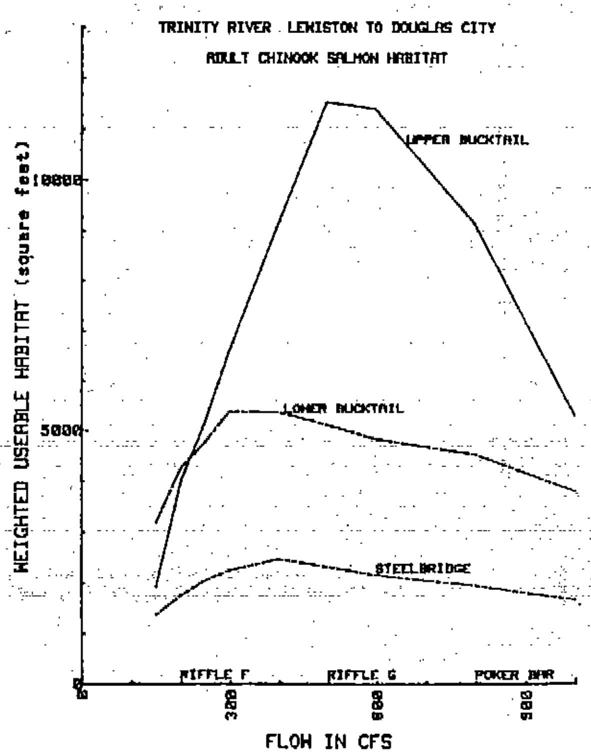


Figure 19

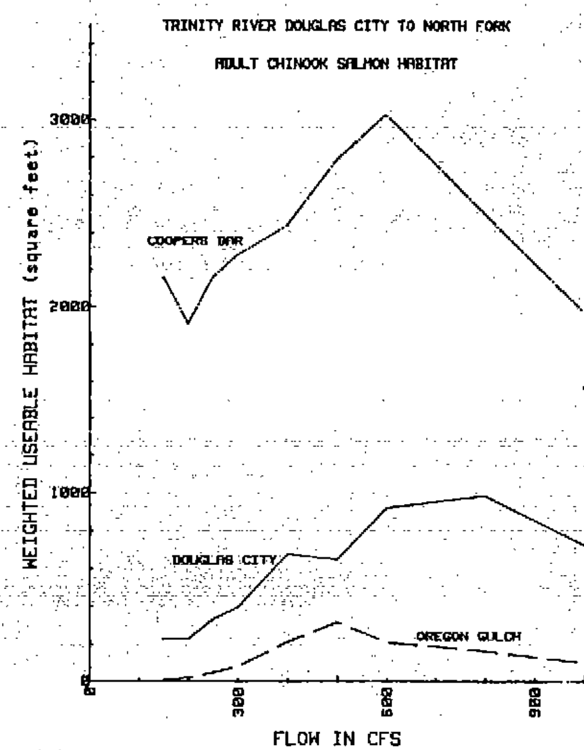


Figure 20

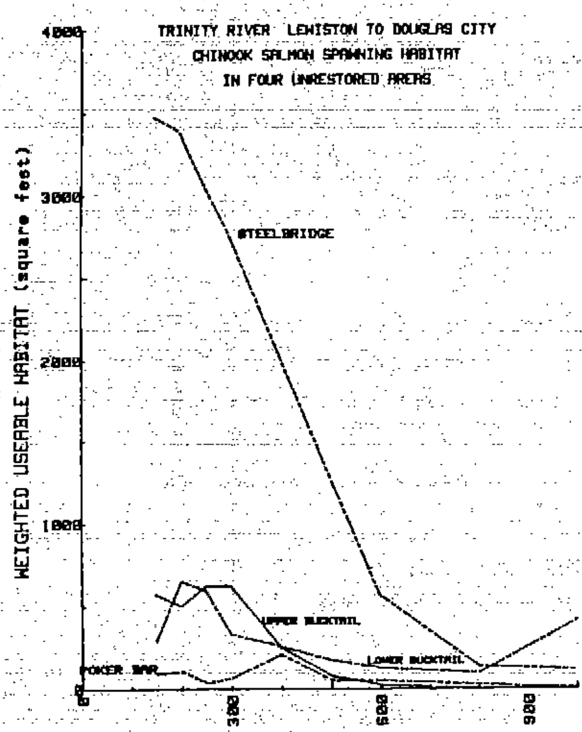


Figure 21

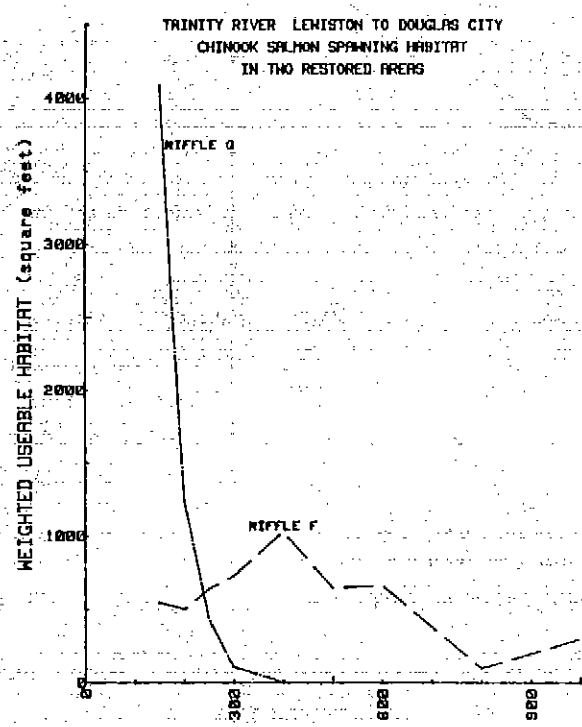


Figure 22

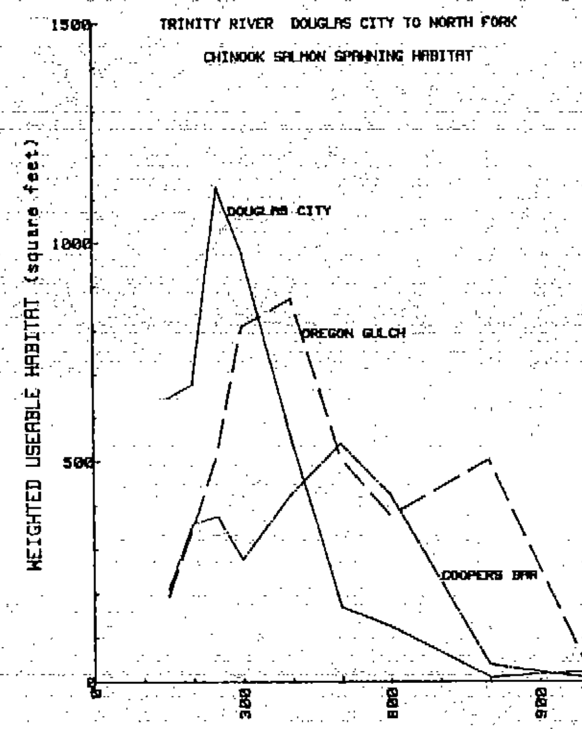


Figure 23

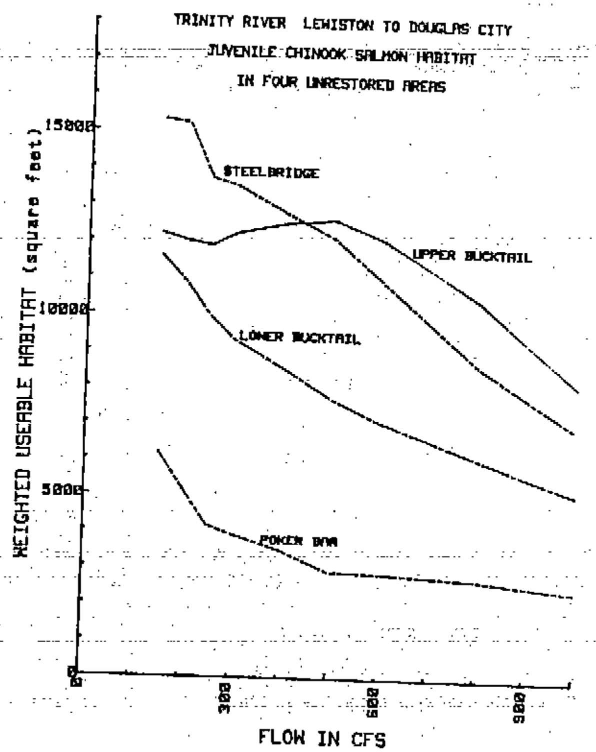
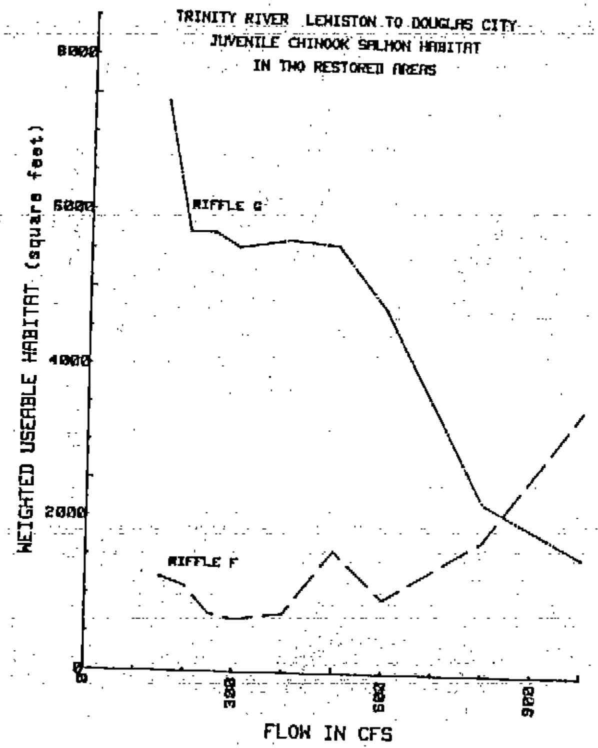


Figure 24



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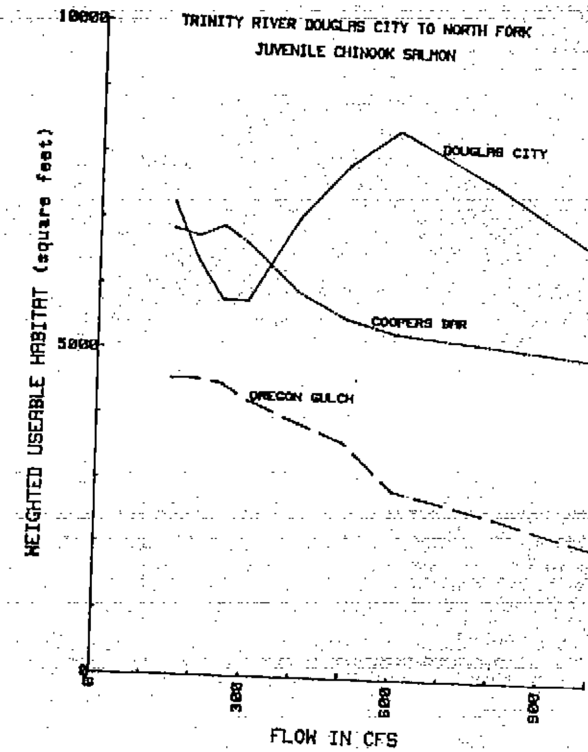


Figure 26

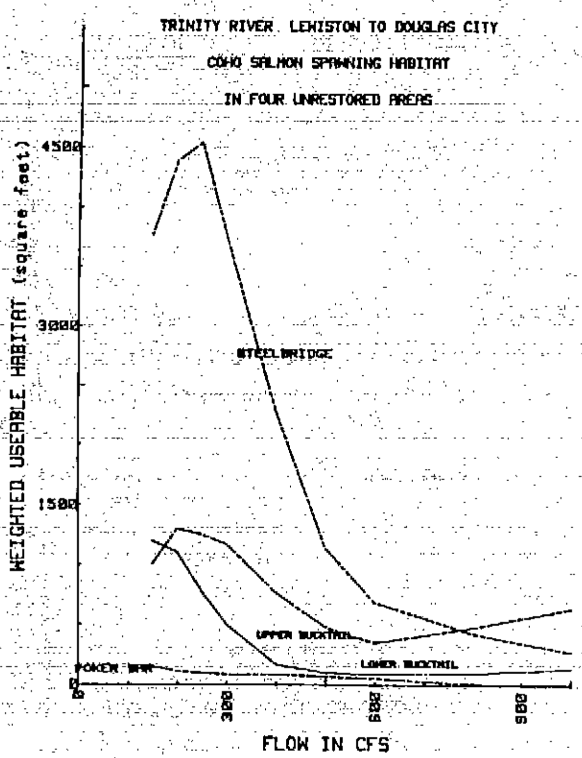


Figure 27

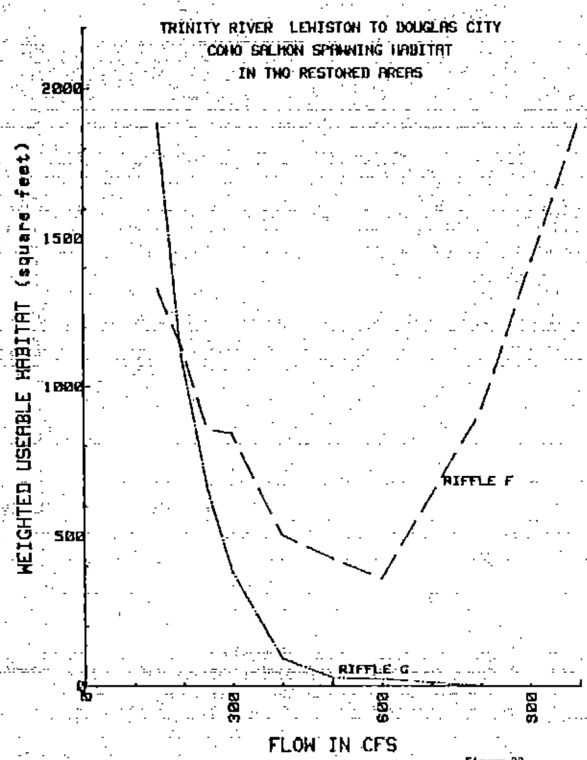


Figure 28

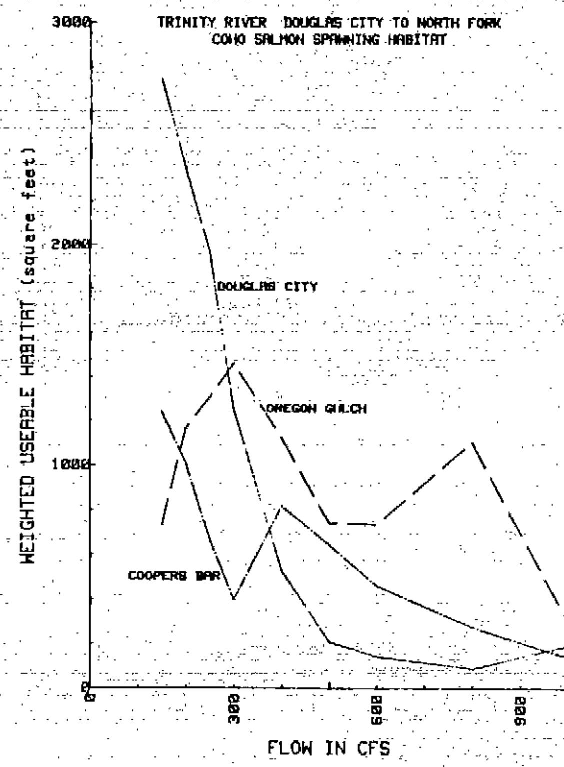


Figure 29

at Riffle F declined to the 600 cfs flow level and then increased as flows increased to 1,000 cfs. Habitat at the three downriver sites peaked at 150 cfs in the Douglas City and Coopers Bar study reaches and at 300 cfs in the Oregon Gulch reach (Figure 29).

Coho salmon fry habitat is shown in Figures 30, 31, and 32. In four of the upper six areas, coho fry habitat peaked at the 150 cfs level (Figure 30). In the other two areas, peaks occurred at 300 and 1,000 cfs (Figure 31). At two of the lower three reaches peak coho salmon fry habitat occurred at 150 cfs with a peak at 600 cfs for the third area (Figure 32).

Brown trout:

Brown trout adult habitat estimates are shown in Figures 33, 34 and 35. Peak habitat occurred at the Upper Bucktail site at a flow of 300 cfs (Figure 33). Relatively high levels of habitat also occurred at the Lower Bucktail and Steel Bridge reaches with peaks at flows of 200 and 400 cfs, respectively.

Brown trout spawning habitat estimtes are shown in Figures 36, 37, and 38. Spawning habitat was most abundant in the Riffle G, Steel Bridge, and Douglas City study reaches at flows of 150, 250, and 150 cfs, respectively. Very little brown trout spawning habitat occurred in the Poker Bar and Oregon Gulch reaches.

Brown trout juvenile habitat estimates are shown in Figures 39, 40, and 41. Highest estimated habitat for juvenile brown trout occurred at the Upper Bucktail Site at a flow of 500 cfs. Relatively high levels of juvenile brown trout habitat existed at all 9 study sites with peaks occurring at 6 of the 9 sites at a flow of 200 cfs or less.

Additional observations:

Calculated useable habitat on Lower Lewiston Riffle (approximately 1.5 miles below Lewiston Dam) and Upper Cemetary Riffle (approximately 2.0 miles below Lewiston Dam) are shown in Tables 5 and 6. This data confirmed suspicions that, on the basis of the evaluative criteria developed for this report, optimum spawning conditions on the restored riffles did not occur at the design level of 250 cfs but rather at flows in the 150-200 cfs range.

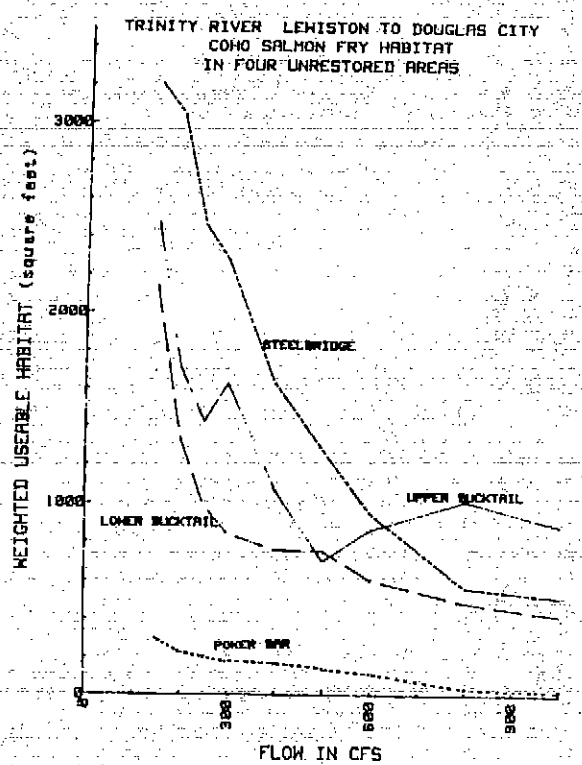


Figure 30

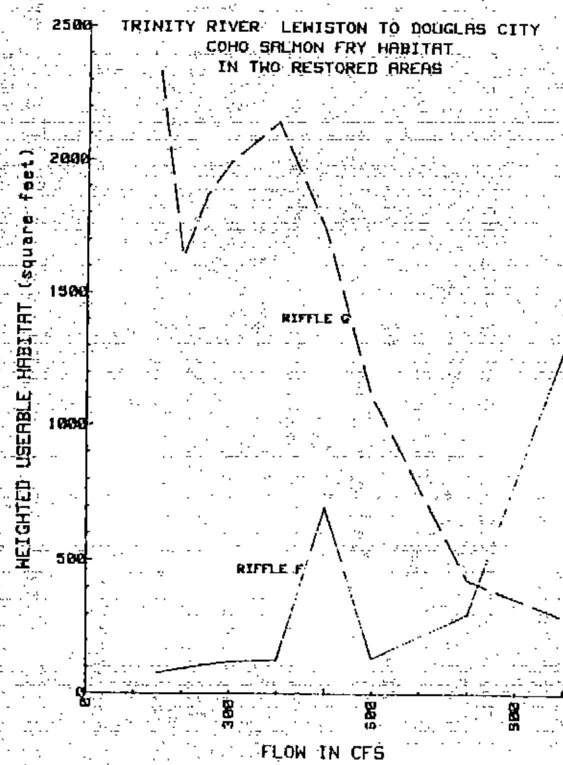


Figure 31

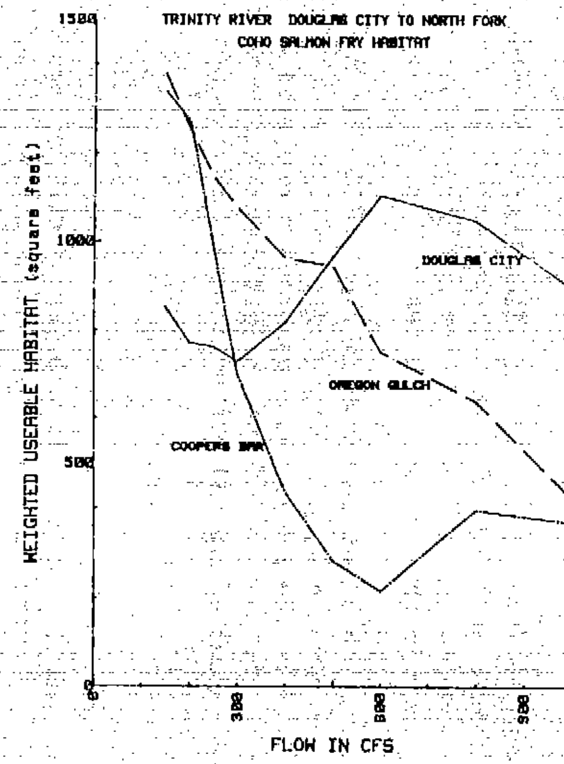


Figure 32

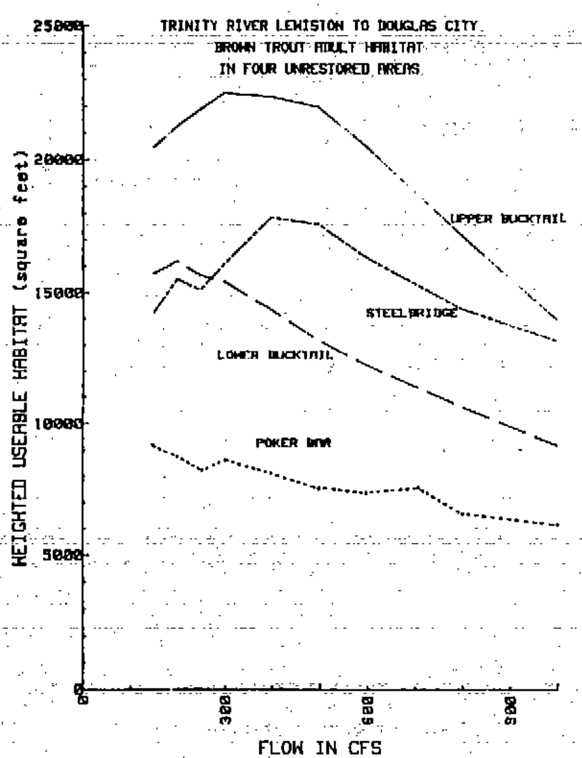


Figure 33

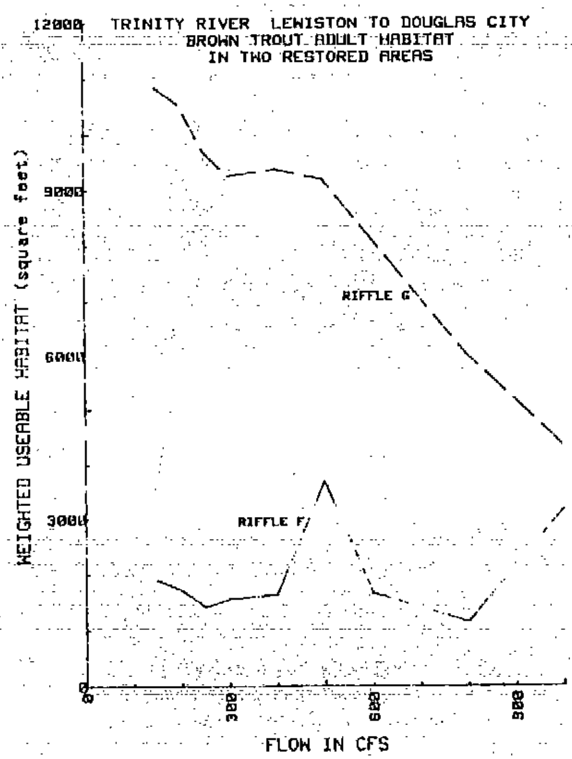


Figure 34

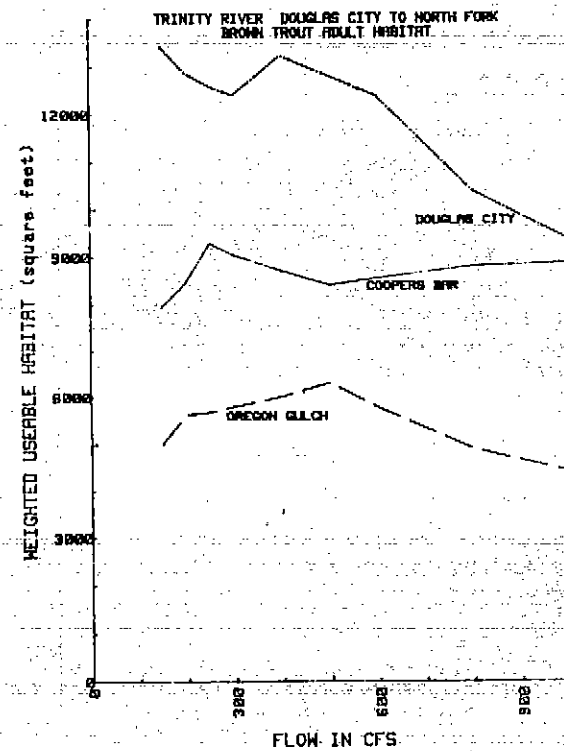


Figure 35

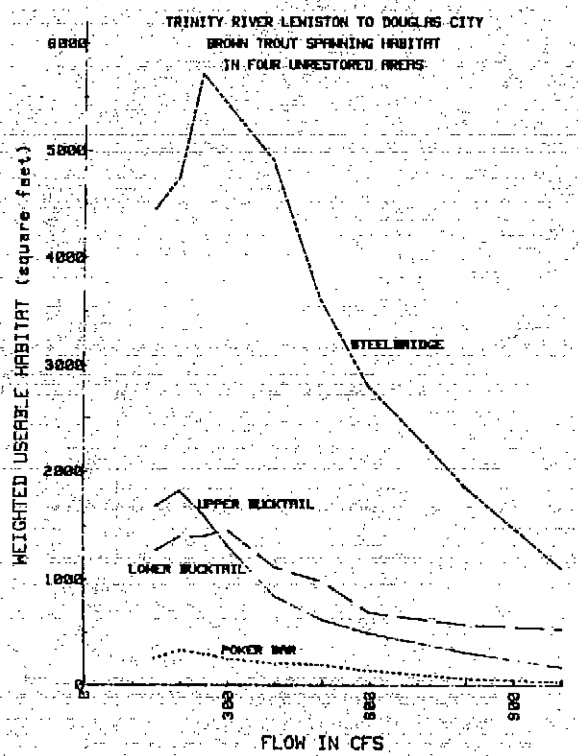


Figure 36

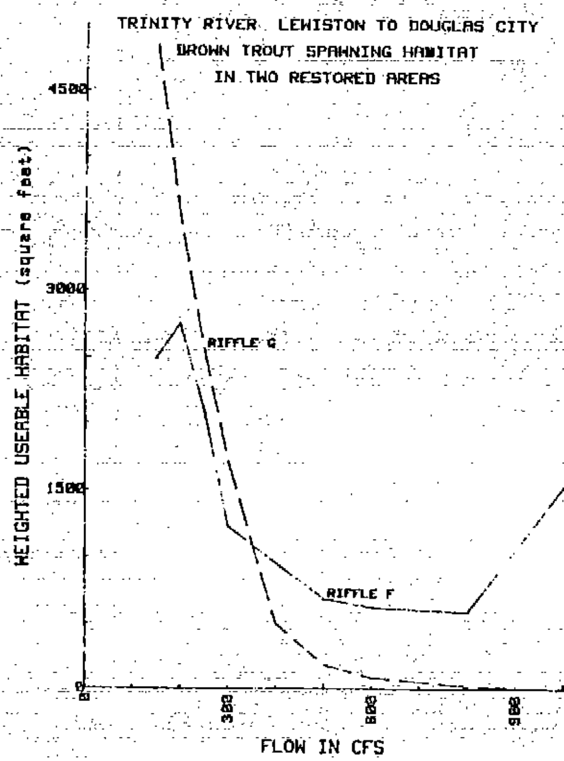


Figure 37

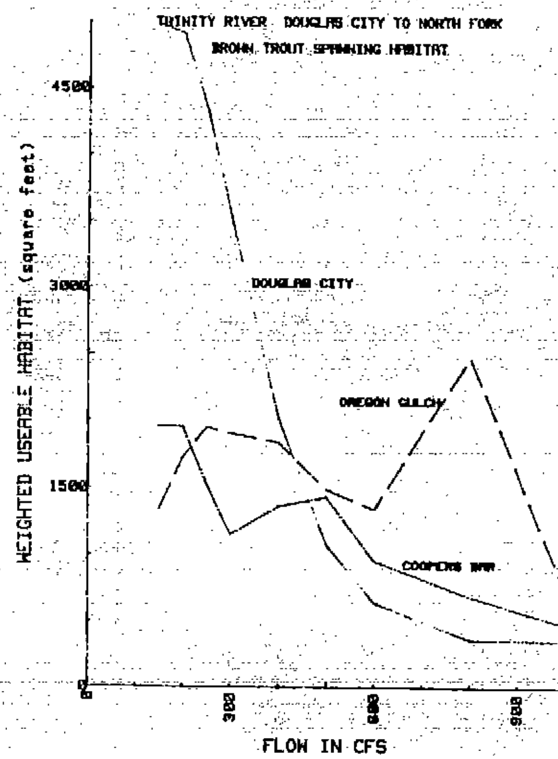


Figure 38

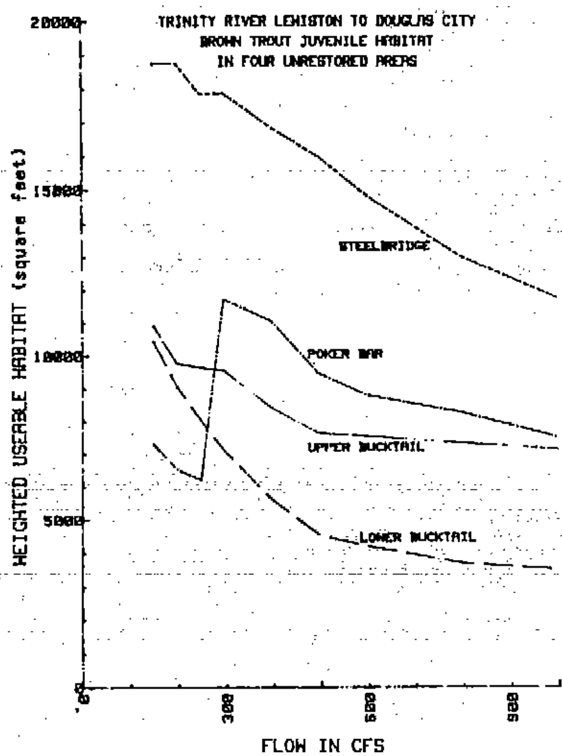


Figure 39

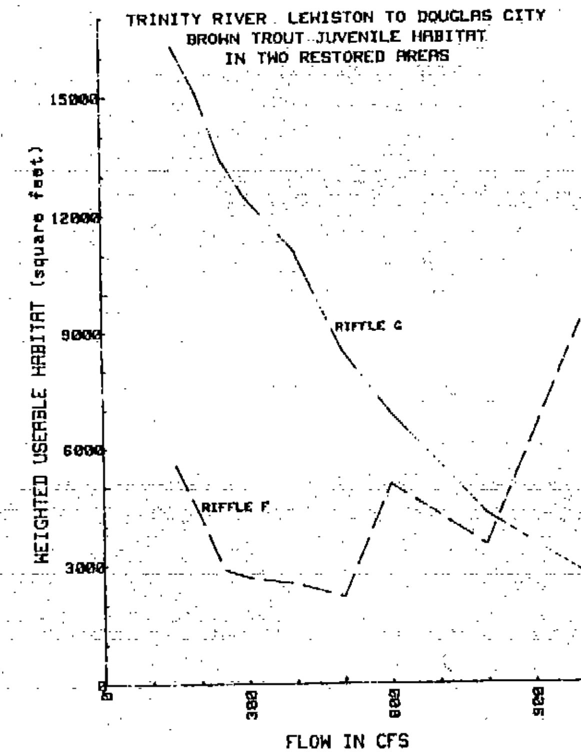


Figure 40

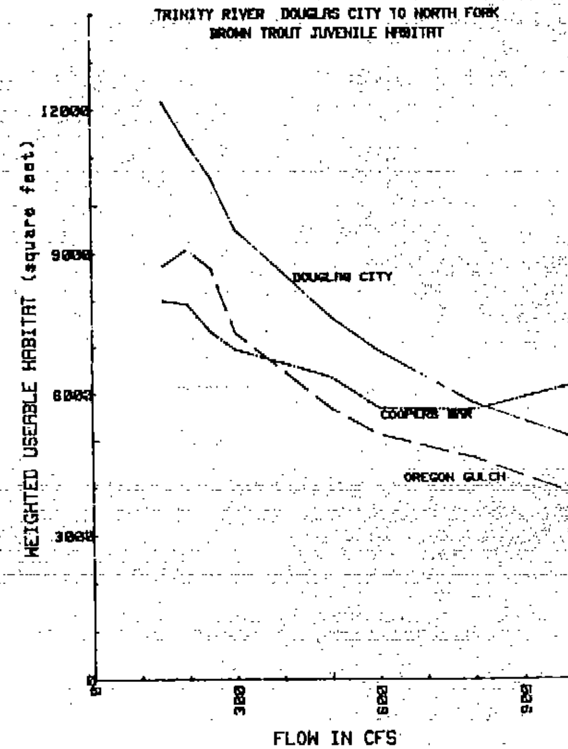


Figure 41

Table 6 Trinity River at Upper Cemetary Riffle
Weighted Usable Habitat
(Square feet per 500 Linear Feet)
Calculated Using IFG HABIN/HABITAT Programs

Chinook Habitat 1/

Flow (cfs)	Adult	Spawning	Juvenile
155	0	32,500	8,000
187	0	26,600	6,400
231	0	16,000	8,800

Steelhead Habitat 1/

Flow (cfs)	Adult	Spawning	Juvenile
155	4,300	24,000	22,000
187	4,000	28,000	18,000
231	3,000	22,500	14,000
302	6,400	21,000	11,000

1/ Values rounded to nearest 100 square feet.

Table 5 Trinity River at Lower Lewiston Riffle
Weighted Usable Habitat
(Square feet per 500 linear feet)
Calculated Using IFG HABIN/HABITAT Programs

Chinook Habitat 1/

Flow (cfs)	Adult	Spawning	Juvenile
146	0	28,400	6,900
193	0	20,000	4,200
233	0	10,300	5,200
300	0	3,300	4,700

Steelhead Habitat 1/

146	3,000	24,300	17,800
193	3,500	25,500	12,900
233	6,900	20,100	13,500
300	4,000	8,400	9,800

1/ Values rounded to nearest 100 square feet.

The relative importance of mainstem Trinity River habitat for various life stages of the chinook and coho salmon, steelhead trout, and brown trout are shown in Table 7. Habitat for brown trout life stages is rated of low importance (priority) because of potential competition between resident brown trout and the anadromous species.

Estimated average monthly base inflows from tributary streams for each study area is shown in Table 8 (DWR data). The extent of flow augmentation in the main river depended on a variety of factors with mouth of the year and number and size of contributing streams (as reflected by increased distance downstream from Lewiston Dam) being obvious major governing factors. Highest tributary flow contributions would occur in March, ranging from an average 67 cfs at Bucktail to 799 cfs at Coopers Bar. Lowest estimated inflows from tributaries occurred during October (August and September only slightly higher) and ranged from 4 cfs at Bucktail to 51 cfs at Coopers Bar.

The tributary inflow data were used together with the useable habitat area projections to determine monthly flow releases from Lewiston Dam which would provide the greatest improvements in main river conditions at the six study areas for the seasonally prevailing salmonid life stages of highest concern (importance for restoration efforts).

The results, presented in Table 9, showed that substantial habitat improvement in the study areas could be obtained with average Lewiston releases ranging from a low of 275 cfs during the winter months to 450 cfs during the summer and totaling 252 thousand acre-feet annually. The monthly releases were then smoothed on a seasonal basis to provide base flows from 300 to 500 cfs and totaling 253,500 acre-feet annually.

With the adjusted Lewiston releases the monthly base hydrograph conditions at Douglas City and Junction City (Coopers Bar) would range from lows of approximately 320 cfs and 350 cfs, respectively, during October to highs of 650 cfs and 1,100 cfs, repsectively, during March. Summer flows (July and August) would average approximately 525 cfs and 575 cfs, respectively, at the two sites. The Lewiston releases and resulting downstream flows are shown in Figure 42.

TABLE 7

SEASONAL OCCURRENCE AND RELATIVE IMPORTANCE OF SALMONID LIFE STAGES IN THE MAINSTEM TRINITY RIVER NORTH FORK TO LEWISTON

SPECIES / LIFE STAGE	SEASONAL OCCURRENCE/RELATIVE IMPORTANCE											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Steelhead Trout												
Adult	H1	H1	H1	M1	M1	L1	L1	L1	L1	M2	M1	H1
Spawning	M2	H2	H2	H2	H2	L2	L2	L2	L2	L2	L2	L2
Juvenile	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1
Chinook Salmon												
Adult	L3	L3	L3	L3	M2	H1	H1	H1	H1	H1	H1	M3
Spawning	L3	L3	L3	L3	L3	L3	L3	L2	M1	H1	H1	M1
Juvenile	M1	H1	H1	H1	H1	M1	M3	M3	M3	M3	M3	M3
Coho Salmon												
Adult	M2	L3	L3	L3	L3	L3	L3	L3	M2	H2	H2	H2
Spawning	M3	L3	L3	L3	L3	L3	L3	L3	L3	M2	M2	M2
Juvenile	M2	M2	H2	H2	M2	M2	M2	M2	M2	M2	M2	M2
Brown Trout												
Adult	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3
Spawning	L3	L3	L3	L3	L3	L3	L3	L3	M3	H3	H3	M3
Juvenile	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3	H3

Seasonal Occurrence:

H - Most frequent periods
M - Moderate occurrence
L - Absent or limited occurrence

Relative Importance (for restoration of reduced anadromous stocks):

1 - Highly important concern
2 - Moderately important concern
3 - Low concern

TABLE 8

CUMULATIVE
"BASE" TRIBUTARY INFLOWS (IN CFS) TO
TRINITY RIVER BETWEEN LEWISTON AND NORTH FORK

Study Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bucktail	30	59	67	50	41	26	6	5	5	4	11	23
Poker Bar	68	136	150	112	92	50	16	9	10	7	25	52
Steel Bridge	77	154	170	127	104	57	17	10	12	8	28	59
Douglas City	143	325	361	274	223	123	39	22	25	17	60	129
Oregon Gulch	226	483	542	412	330	184	59	34	38	27	90	194
Coopers Bar	370	706	799	647	520	292	95	51	51	41	161	305

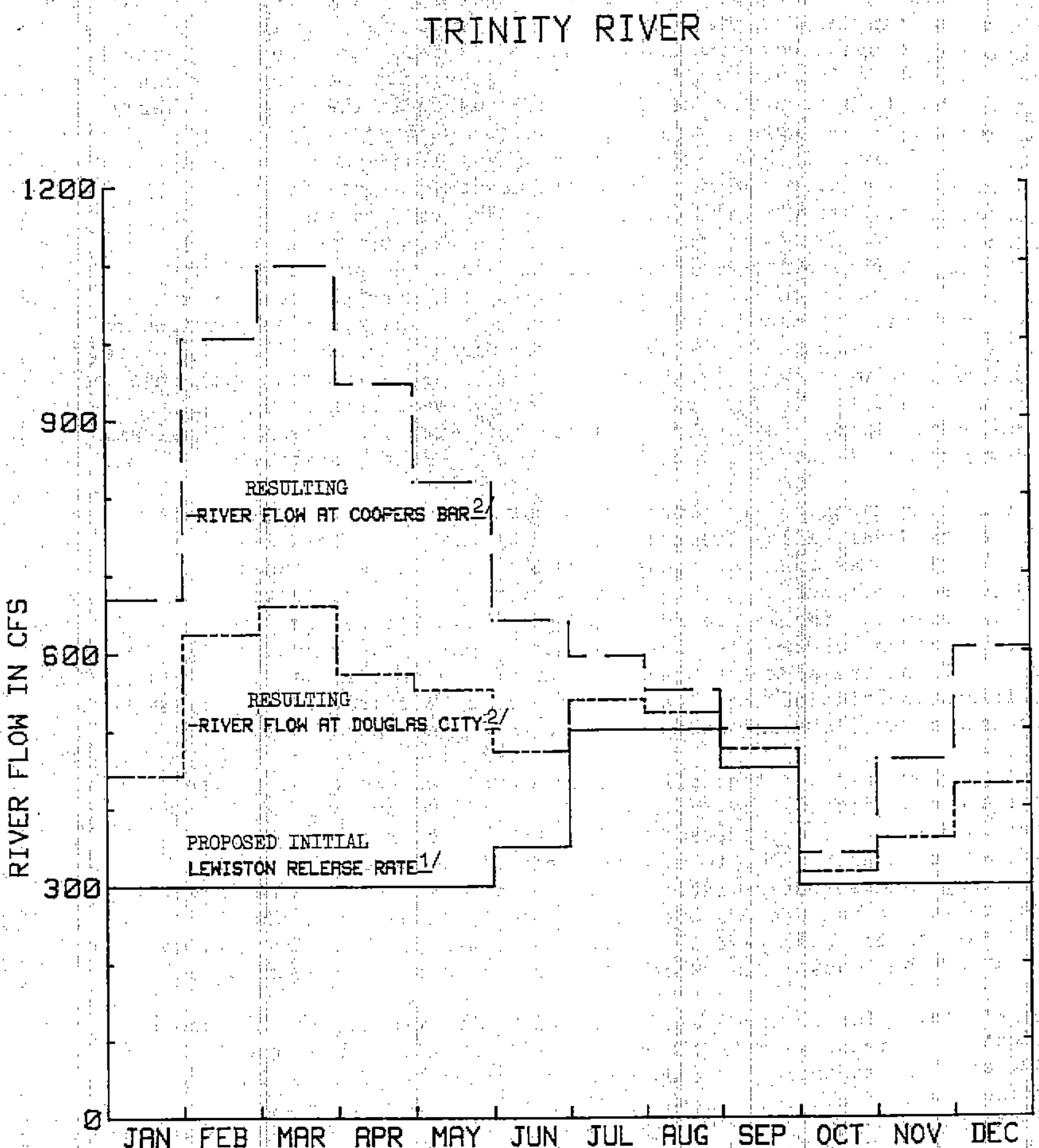
TABLE 9

Required Releases from Lewiston Reservoir for Maximum Habitat Improvement for Critical Salmon and Steelhead Life Stages (Releases in Cubic Feet per Second)

Critical Life Stage	Release Required During Months of Most Frequent Life Stage Occurrence											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Adult steelhead	400	350	350	400	400	—	—	—	—	—	400	350
Steelhead spawning 1/	—	250	200	250	250	—	—	—	—	—	—	—
Juvenile steelhead	250	300	300	350	350	350	400	400	400	400	350	300
Adult chinook salmon	—	—	—	—	—	500	500	500	500	500	500	—
Chinook salmon spawning 2/	—	—	—	—	—	—	—	—	—	200	200	—
Juvenile chinook salmon	200	200	200	200	200	200	—	—	—	—	—	—
Average Required: total (252,000 acre-feet)	275	275	275	325	325	350	450	450	450	350	325	375
Adjusted Release: total (253,500 acre-feet)	300	300	300	300	300	350	500	500	450	300	300	300

1/ Steelhead spawning is a critical life-stage, but bechuse most spawning normally occurs in tributary streams, flows to improve main river spawning conditions were not used to determine average required releases from Lewiston.

2/ Fall chinook salmon spawning is a critical life-stage highly dependent on main river conditions, therefore flows to improve river spawning conditions were given greater consideration (2X) in determining average release requirements.



1/ Initial release schedule as recommended in this report. With implementation of ultimate flow schedule. The minimum Lewiston release would be 400 cfs and flows downstream would increase proportionately.

2/ Resulting flows calculated as sum of Lewiston release plus estimated tributary base inflow.

Figure 42

Discussion and Conclusions

The instream flow assessment method used generally worked well for simulation of flows within the desired range of 150 to 1,000 cfs. However, the flows measured at Coopers Bar were closely spaced (745-937 cfs) and a relatively wide range of field data (velocities and depths) were obtained for stations there. When this situation occurs the confidence in the stage/discharge relationship is decreased, especially when projecting to low flow conditions (Bovee, 1978). Some difficulty was also encountered with flow calibration at a few stations where negative velocities were recorded associated with the occurrence of eddies. In some instances it was necessary to assign absolute values to some or all of the negative velocity measurements. Although the negative flows were small compared to the dominant channel, the reversal of values caused the corresponding discharge estimates for the affected sections to increase proportionate to the velocity reversals. Eddies were encountered at one or more stations in each of the lower study areas resulting in a tendency to slightly under estimate habitat by over estimating the corresponding flow. This occurred since flow direction (either upstream or downstream) was not a concern in determining usable habitat.

Habitat projections for the Poker Bar reach, which has been seriously affected by Grass Valley Creek decomposed granite sediments, were consistently lower than for those reaches above and below the area of major sediment influence. A level of habitat comparable to that measured at Steelbridge is believed to have existed in the Poker Bar reach before being lost to inundation by the granitic sands. If the Grass Valley Creek sediment is controlled, a significant portion of the river habitat could be restored with increased river flows and sediment flushing or mechanical removal.

The data show that substantially higher amounts of habitat for most species can be obtained by increasing base flows above present levels. However, the increased habitat can not be maintained if tributary sediment inflow is not substantially reduced to prevent continuing channel deterioration. It is suspected that the relatively high quality of habitat measured in the Steel Bridge reach has diminished in the past year as bedload sediments have continued to move downriver from Grass Valley Creek (Miller, personal communication).

Habitat graphs for restored Riffles F and G (Figures 14, 17, 22, and 25 indicate that relatively little habitat (8% or less of the actual total area) is suitable for spawing or rearing of juvenile salmon and steelhead within the full range of flows (150-1,000 cfs) examined -- this in spite of the fact that they were designed to accommodate spawning salmon at a flow of 250 cfs. Reasons for the low projections of spawning usable habitat include excessive velocities within the main channel area, excessive depths, and less than optimum substrate materials. The fact that the channels are nearly vertically walled (Riffle G and the left bank of Riffle F) rather than gently sloping prevents the spread of water at higher flows onto new gravels as would occur on a more natural riffle. Apparently at the higher releases, the river was spilling out of the confines of the Riffle F channel and providing habitat along the right bank as can be seen in Figure 2. The amount of usable habitat at the restored Riffle F was less than 8% of estimated total surface area which is no better than was recorded for adjacent unrestored areas.

Substantial additional riffle restoration work will be needed to improve the spawning area. The spawning riffles can be designed to maximize usable areas based on flows provided to meet the requirements of the other critical life stages.

Flow releases in the range of 300 to 400 cfs are required to maximize the habitat available for juvenile steelhead trout, which is ranked as a first-order consideration. Higher flows to 500+ cfs could increase the total amount of suitable habitat available by lengthening the reach of the river in which more acceptable summer water temperatures resulting from increased mainstem flow would occur. It is probable that the graphs for the three lower river stations (Figures 18, 26, 32 and 41) do not truly reflect available summer habitat for juvenile salmonids below 300 cfs, since it is suspected that temperature may be a limiting factor in these areas. Additional habitat for juveniles could also be provided with better velocity and depth distributions by restoring stream banks to a more natural gradually-sloping configuration. Flows for maintenance of habitat for juvenile steelhead trout would be required year-round because as one group smolts and emigrates to the sea it is being replaced by a new group emerging from gravels and descending from tributary streams.

In order to improve juvenile chinook habitat, Lewiston releases would need to be substantially below 150 cfs during much of the time. In nearly all instances total river flows above 150 cfs resulted in less projected rearing habitat for juvenile chinook salmon. This too, is apparently due to the severe constriction of the present river channel with a corresponding lack of "feather" edges with slow velocities. Any increased flows provided to meet critical needs of other life stages should be accompanied by mechanical river channel restoration to improve habitat for juvenile chinook salmon. Consideration of juvenile chinook salmon needs should be included in all spawning riffle restoration work.

Adult steelhead trout and chinook salmon holding area in the Lewiston to Douglas City reach is also a high magnitude concern. Significant increases in available adult holding habitat for these species occurred with releases in the 300 to 500 cfs range. Projections of adult steelhead trout habitat during January increased by over 1/3 at a release of 400 cfs as opposed to 150 cfs with the major gains occurring at the Steel Bridge and Upper Bucktail stations. Available habitat for adult chinook salmon during August more than doubled as flow releases increased from 150 to 500 cfs. Again the greatest habitat gains occurred in the Bucktail and Steel Bridge areas.

Flows for meeting habitat needs for the life stages of brown trout and coho slamon were not considered important for achieving restoration of anadromous stocks. Past attempts to establish a viable anadromous brown trout fishery have not materialized and resident brown trout may be competing with and preying on juvenile salmon and steelhead trout. Coho stocks in the Trinity system are believed to be substantially maintained by Trinity Hatchery production. Instream flows provided for other species should adequately meet the needs of coho salmon and sustain a resident brown trout fishery.

The habitat data indicates that releases from Lewiston Dam should be maintained at 300 to 400 cfs for protection of adult and juvenile steelhead trout and that seasonal flow increases to 500 cfs should be provided to meet the flow needs for adult chinook salmon. A further consideration in the short-term would be to maintain flows during the chinook salmon spawning season, September through December, to a range near 300 cfs in order to minimize loss of currently available spawning habitat due to excessive velocities within the existing river channel. Because of the projections of limited habitat for spawning, in both restored and natural areas, consideration should be given to reconstruction of spawning riffles to accommodate the 400 cfs base flows usable for habitat for adults and juvenile steelhead. This would provide a greater spawning area and allow the needs of the other important life stage to also be met.

The 254,000 acre-feet annual base flow schedule for releases from Lewiston Dam to optimize main river habitat for salmon and steelhead trout under existing river channel conditions as compared with the present schedule of 120,500 acre-feet is shown in figure 1. An additional block of approximately 33,000 acre-feet should be reserved for various fishery management needs including freshet simulation for stimulating and assisting fish migration and for flushing sediments from spawning gravels. More study into the role that high flows play during periods of attempted outmigration by juveniles and upriver migration by adults is needed, but the current lack of such flows is suspected to be a contributory factor in fishery declines. Unless future studies show otherwise, increased flows to stimulate migration should be maintained if the Trinity River is to successfully function both as a fish producer and as a transport corridor for fish production at Trinity Hatchery.

There is no guarantee that increased flows will bring about a full restoration of Trinity River salmon and steelhead trout stocks. However, it does show that the available habitat could be increased to accommodate increased production. Additional studies would be required to quantitatively evaluate production gains obtained with improved flow conditions.

With fall and early spring flows held to 300 cfs to more fully utilize existing habitat, sufficient production of young fish from the spawning and rearing areas may not be obtained to fully restore salmon and steelhead runs. Creation of additional habitat by mechanical alteration of the stream channel has been proposed as a restoration tool. To assure that sufficient habitat is available for all life stages any additional mechanical restoration activities should be designed to accommodate a base flow of up to 400 cfs for spawning and rearing purposes; and additional water should be reserved to increase the minimum flow to 400 cfs, as necessary, to reach desired production levels.

Requirements to provide base flows of 400 cfs--increasing to 500 cfs during the summer--would consist of approximately 308,000 acre-feet, and together with flows to provide for migration and attraction purposes (33,000 acre-feet) would total approximately 340,000 acre-feet annually. The acretions from tributaries significantly contribute to mainstem habitat during certain periods and should be protected as necessary from any future offstream diversions.

Recommendations

It is recommended:

1. That the following schedules of base flow releases from Lewiston Dam be adopted as a general guide for purposes of furthering efforts for restoration of anadromous fisheries habitat in the mainstem Trinity River:

	Present	Eventual
January through May:	300 cfs	400 cfs
June:	350 cfs	400 cfs
July through August:	500 cfs	500 cfs
September:	450 cfs	450 cfs
October through December:	300 cfs	400 cfs

2. That an additional minimum block of 33,000 acre-feet be reserved for special flow augmentation needs as may be determined necessary by various other ongoing fisheries related investigations.

3. That tributary inflows below Lewiston Dam be protected from future appropriation and diversion.

4. That a comprehensive program of stream channel rehabilitation should be developed and undertaken to improve salmonid spawning and rearing conditions in the Trinity River in the Lewiston to Douglas City reach based on a minimum release of 400 cfs from Lewiston Dam.

5. That ongoing salmon and steelhead studies in the Trinity River Basin should be expanded where necessary to investigate responses of fish stocks to improved habitat conditions resulting from increased flows and to determine what, if any, additional flow modifications are necessary.

Literature Cited

Bovee, Ken D. January, 1978. Probability-of-Use Criteria for the Family Salmonidae. Instream Flow Information Paper No. 4. U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

Bovee, Ken D. and Robert Milhous. August, 1978. Hydraulic Simulation In Instream Flow Studies: Theory and Techniques. Instream Flow Information Paper No. 5. U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

California Department of Water Resources. April, 1978. Grass Valley Creek Sediment Control Study.

Hubbell, Paul. August, 1973. A Program to Identify and Correct Salmon and Steelhead Problems in the Trinity River Basin. California Department of Fish and Game.

Main, Robert B. August, 1978 a. Habitat Program User Manual (draft). U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

Main, Robert B. August, 1978 b. IFG4 Program User Manual (draft). U.S. Fish and Wildlife Service Cooperative Instream Flow Group.

Smith, Felix E. September, 1976. Water Development Impact on Fish Resources and Associated Values of the Trinity River, California in Instream Flow Needs, Vol. II. American Fisheries Society.

Table A-1

Trinity River at Upper Bucktail

Flow	Chinook Salmon			Steelhead			Coho		Brown Trout		
	Adult	Spawning	Juvenile	Adult	Spawning	Juvenile	Spawning	Fry	Adult	Spawning	Juvenile
150	1932	573	12206	2140	318	13810	1199	2471	20461	1687	10914
200	3987	504	12010	3229	370	13720	1105	1714	21240	1827	9763
250	5188	626	11888	4903	400	14953	774	1423	21869	1608	9635
300	6626	442	12223	7165	391	16911	504	1628	22484	1317	9540
400	9127	249	12504	12437	283	20292	167	1070	22347	843	8402
500	11532	78	12619	13623	174	21006	99	700	21953	623	7926
600	11400	22	12082	12889	92	20032	86	862	20482	496	7533
800	9154	2	10445	8485	2	16494	98	1014	17180	312	7325
1000	5297	0	8161	6097	0	12587	136	887	14011	173	7119

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

Table A-2

Trinity River at Riffle F

Flow	Chinook Salmon Adult	Chinook Salmon Spawning	Chinook Salmon Juvenile	Steelhead Adult	Steelhead Spawning	Steelhead Juvenile	Coho Spawning	Coho Fry	Brown Trout Adult	Brown Trout Spawning	Brown Trout Juvenile
150	0	547	1216	245	1639	5871	1329	79	1895	2491	5562
200	0	502	1103	454	1507	4443	1129	95	1721	2749	4272
250	0	642	748	198	1136	2745	853	111	1419	2104	2895
300	0	728	677	171	308	2287	840	122	1560	1229	2692
400	0	1030	760	235	656	1982	503	130	1639	954	2195
500	0	647	1574	1386	663	3543	425	698	3695	686	5043
600	0	667	958	505	256	2371	357	136	1661	623	3490
800	0	99	1735	48	11	3043	908	303	1143	588	9230
1000	0	301	3460	294	0	7174	1900	1289	3171	1528	13482

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

Table A-3

Trinity River at Riffle G

	Chinook Salmon			Steelhead			Coho		Brown Trout		
Flow	Adult	Spawning	Juvenile	Adult	Spawning	Juvenile	Spawning	Fry	Adult	Spawning	Juvenile
150	0	4087	7414	10466	3878	17457	1885	2333	10846	4844	16282
200	0	1252	5729	10450	2307	15392	1087	1633	10538	3534	15091
250	0	436	5731	6220	620	13381	662	1868	9701	2576	13436
300	0	106	5536	3660	85	10838	382	1993	9261	1723	12478
400	0	2	5642	2325	0	8938	91	2145	9378	499	11131
500	0	0	5580	1734	0	8680	26	1743	9198	185	8522
600	0	0	4762	1665	0	8151	22	1107	8145	86	6895
800	11	0	2222	3760	0	5942	1	428	6019	23	4288
1000	12	0	1527	1462	0	3139	0	293	4352	2	2783

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet

Table A-4

Trinity River at Lower Bucktail

	Chinook Salmon			Steelhead			Coho		Brown Trout		
Flow	Adult	Spawning	Juvenile	Adult	Spawning	Juvenile	Spawning	Fry	Adult	Spawning	Juvenile
150	3203	293	11587	5582	342	17627	1008	2137	15735	1277	10441
200	4263	654	10879	6528	480	17935	1300	1332	16191	1406	9070
250	4783	597	9946	7001	629	18000	1250	988	15660	1405	8040
300	5386	333	9321	6580	718	17723	1171	841	15432	1468	7087
400	5374	258	8543	7588	499	17150	770	757	14379	1117	5584
500	5115	194	7703	8271	390	16114	485	754	13200	983	4521
600	4826	125	7074	7478	323	14990	353	604	12237	690	4198
800	4529	97	6096	6372	163	13291	483	488	10637	577	3694
1000	3807	417	5142	5463	124	11185	640	422	9178	538	3512

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

Table A-5

Trinity River at Poker Bar

	Chinook Salmon			Steelhead			Coho		Brown Trout		
Flow	Adult	Spawning	Juvenile	Adult	Spawning	Juvenile	Spawning	Fry	Adult	Spawning	Juvenile
150	0	93	6182	5077	78	13414	149	518	9221	501	11708
200	0	106	5179	8205	114	13039	109	375	8869	621	11044
250	7	38	4162	9815	84	11705	96	257	8174	581	9441
300	13	68	3910	9969	82	11093	84	220	8662	449	8796
400	5	208	3474	7290	74	8780	83	180	8117	385	8258
500	4	51	2902	4302	136	6911	67	141	7552	344	7508
600	7	50	2869	3095	95	5484	52	131	7296	254	6801
800	7	29	2733	2312	0	4667	11	135	6510	104	6189
1000	2	6	2451	1738	0	4328	8	121	6197	51	5506

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

Table A-6

Trinity River at Steelbridge Campground

Flow	Chinook Salmon Adult	Chinook Salmon Spawning	Chinook Salmon Juvenile	Steelhead Adult	Steelhead Spawning	Steelhead Juvenile	Coho Spawning	Coho Fry	Brown Trout Adult	Brown Trout Spawning	Brown Trout Juvenile
150	1387	3475	15318	3322	681	22582	3767	3203	14255	4450	18745
200	1770	3388	15222	5712	1042	24512	4388	3044	15519	4741	18743
250	2068	3072	13709	8994	1771	25008	4542	2462	15115	5718	17832
300	2266	2781	13525	12004	1770	26277	3789	2277	16092	5438	17851
400	2453	2046	12795	14355	1987	26663	2294	1630	17829	4913	16835
500	2323	1294	12116	13784	1813	25398	1146	1279	17581	3616	15964
600	2156	571	10951	11584	1320	22880	692	950	16333	2805	14821
800	1956	138	8664	8278	427	16853	432	565	14407	1860	12994
1000	1676	117	6928	6205	151	13500	275	516	13197	1109	11753

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

Table A-7

Trinity River at Douglas City Campground

Flow	Chinook Salmon Adult	Chinook Salmon Spawning	Chinook Salmon Juvenile	Steelhead Adult	Steelhead Spawning	Steelhead Juvenile	Coho Spawning	Coho Fry	Brown Trout Adult	Brown Trout Spawning	Brown Trout Juvenile
150	228	644	7230	7340	715	13928	2744	850	13414	4978	12158
200	228	676	6366	9558	960	13733	2342	770	12864	4912	11319
250	334	1127	5773	9015	1188	13240	1967	761	12581	4328	10582
300	396	979	5763	7718	1003	13005	1251	728	12395	3544	9508
400	676	548	7027	6328	682	13098	525	816	13220	2019	8600
500	648	169	7856	4576	411	12465	208	965	12796	1081	7646
600	921	125	8402	3875	200	12436	141	1104	12375	646	6909
800	685	10	7588	4574	42	11796	87	1046	10392	368	5786
1000	725	24	6625	4841	13	10691	193	895	9372	358	5049

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

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Table A-8

Trinity River at Oregon Gulch

	Chinook Salmon			Steelhead			Coho		Brown Trout		
Flow	Adult	Spawning	Juvenile	Adult	Spawning	Juvenile	Spawning	Fry	Adult	Spawning	Juvenile
150	9	194	4537	2712	99	9565	732	1378	5015	1342	8738
200	21	347	4536	2545	35	10395	1165	1255	5616	1722	9087
250	48	518	4477	2664	91	10794	1306	1145	5669	1943	8675
300	81	808	4228	2721	186	9804	1463	1077	5788	1899	7300
400	212	871	3897	3220	362	8838	1119	962	5995	1833	6491
500	317	506	3596	3641	461	7601	741	943	6302	1490	5675
600	209	377	2865	2638	392	6244	734	751	5758	1345	5128
800	162	503	2490	1582	460	4525	1102	637	4880	2477	4613
1000	98	19	2055	1472	78	3477	300	425	4407	746	3859

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

Table A-9

Trinity River at Coopers Bar

Flow	Chinook Salmon			Steelhead			Coho		Brown Trout		
	Adult	Spawning	Juvenile	Adult	Spawning	Juvenile	Spawning	Fry	Adult	Spawning	Juvenile
150	2158	211	6845	2933	460	10329	1240	1339	7946	1951	7983
200	1910	358	6735	3880	465	10678	1010	1272	8453	1948	7913
250	2160	375	6898	3794	514	11055	668	987	9281	1528	7310
300	2281	277	6634	4190	457	11076	397	699	9036	1157	6937
400	2441	427	5919	4751	429	11213	817	437	8702	1366	6646
500	2786	539	5525	5105	363	11328	642	283	8402	1435	6349
600	3031	425	5304	5363	268	11182	460	217	8546	960	5694
800	2507	39	5138	4121	162	9834	275	396	8785	693	5643
1000	1975	7	4964	3590	90	9536	140	369	8858	485	6151

Flow in cubic feet per second.

Habitat in square feet per 500 linear feet.

APPENDIX B

IFG4 Program

The IFG4 program utilizes two or more sets of stage and velocity measurements taken at different discharges to establish a least-squares fit of log stage versus log discharge, and log velocity vs log discharge for each measurement point on the cross section. Input to the program may be taken directly from the field notes. Required inputs are:

1. Water surface elevation at each cross section.
2. Velocities at specified intervals across section.
3. Ground elevation (cross sectional profile).
4. Distance between cross sections.
5. Estimate of substrate composition at each velocity measurement point.

Given these inputs, the program computs the discharge for each set of calibration measurements. Outputs from the program include:

1. Station indexing
2. Distance across transect from zero point
3. Average depth of channel subsection
4. Average velocity of channel subsection
5. Substrate of channel subsection

These parameters may be obtained for up to 100 channel cross section subdivision.

For each discharge simulated at each cross section the program also outputs an "adjustment factor". For a given discharge, the depths and velocities across the section are calculated independently. If the predicted depths and velocities are accurate, a discharge calculated from these variables should equal the discharge originally requested. The "adjustment factor" is a ratio between the discharge calculated from these simulated parameters and the discharge requested. This factor can be used as an indicator of the accuracy of the predictions; the closer to 1.0 the ratio is, the better the predictions. If the adjustment factor deviates significantly from 1.00 ± 10 percent it indicates that some change has occurred on the stage-discharge relationship, and either more measurements are needed, or some manipulation of the data is needed to calibrate the model. This most frequently occurs at low flow extrapolations, and overbank, high flows.

APPENDIX C

HABITAT Program

The IFG-3, or HABITAT program, is the core to the IFG incremental method. This program uses hydraulic input data from either the PSEUDO or IFG-4 hydraulic simulation programs or direct measurements. These hydraulic data are interfaced with probability criteria for specified life stages of different species. An adjunct to the HABITAT program is a curve maintenance program (CRVMNT) which contains digitized versions of probability-of-use curves for each life stage and species for which criteria have been developed. The appropriate curve sets are accessed by means of a catalog number, which is input to the program in the control deck.

Having accessed the appropriate curve sets for the desired life stages and species, the HABITAT program computes the weighted useable area for the stream reach at each discharge simulated with the hydraulic model. For each species, life stage, and discharge, two-way matrix tables may be obtained as output (velocity versus depth, velocity versus substrate, or depth versus substrate).